



Università degli Studi di Trieste

Dipartimento di Ingegneria e Architettura

Laurea Magistrale: Ingegneria Civile

Corso di INFRASTRUTTURE AEROPORTUALI

Lezione 07: Capacità aeroportuale

Roberto Roberti

Tel.: 040/558.3588

E-mail: roberto.roberti@dia.units.it



Anno accademico 2016/2017

Argomenti

Definizioni di capacità

Componenti della capacità aeroportuale

Fattori di capacità

Capacità e ritardi delle runway per la pianificazione

Capacità oraria Runway

Capacità oraria Taxiway

Capacità oraria gate

Capacità oraria Aeroporto

Calcolo ritardi sulle runway

Capacità di una singola runway

VFR: 50 – 100 operazioni / ora

IFR: 50 –70 operazioni / ora



Modalità operative sulle runway

APPROCCI SIMULTANEI

Approcci indipendenti: la separazione minima tramite radar, sulle diverse piste, non è prescritta (se le piste sono opportunamente distanziate).

Approcci dipendenti: la separazione minima tramite radar, sulle diverse piste, è prescritta.

PARTENZE SIMULTANEE

Partenze indipendenti: Partenze che avvengono nella stessa direzione simultaneamente (se le piste sono opportunamente distanziate).

APPROCCI E PARTENZE SEGREGATI

Operazioni segregate: una pista è utilizzata per i decolli e l'altra per gli atterraggi

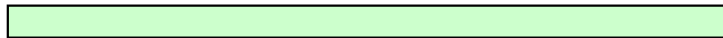
Operazioni semi – miste: una pista è utilizzata o per gli atterraggi o per i decolli e l'altra può essere utilizzata sia per i decolli che per gli atterraggi.

Operazioni miste: tutte le altre

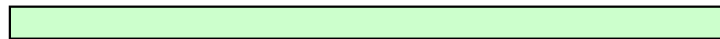
Piste parallele



SOGLIE ALLINEATE

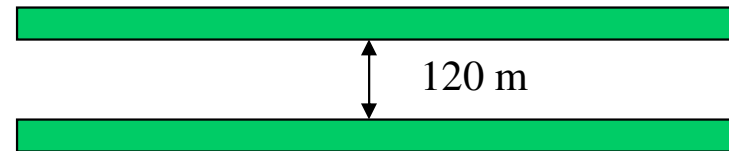


SOGLIE SFALSATE

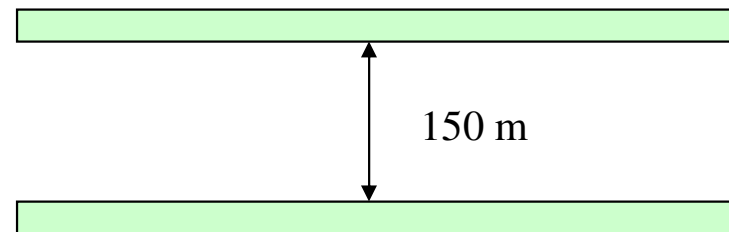


Separazione tra runway non strumentali

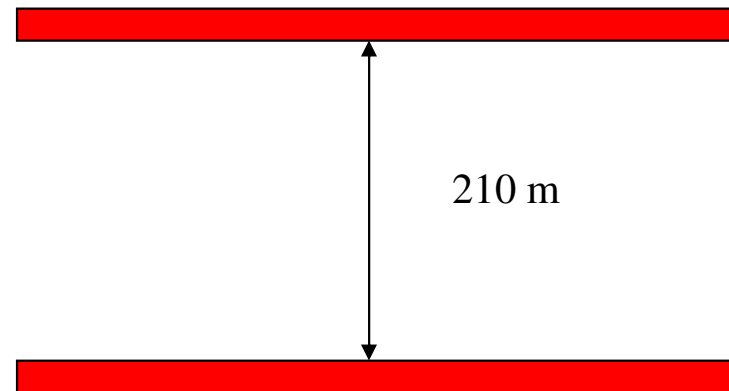
Codice numerico più alto delle piste: 1



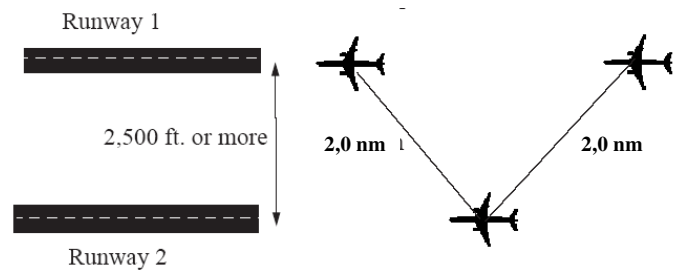
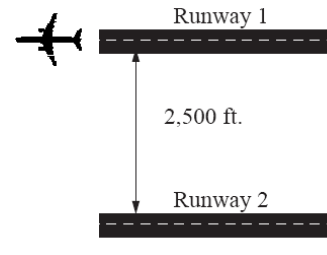
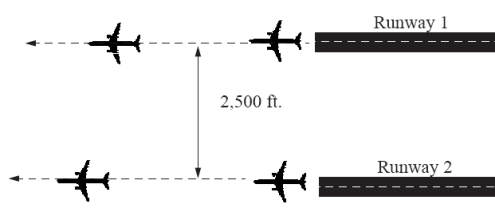
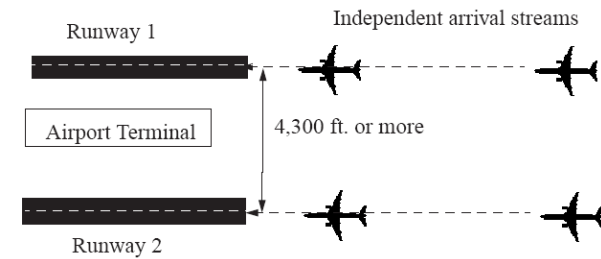
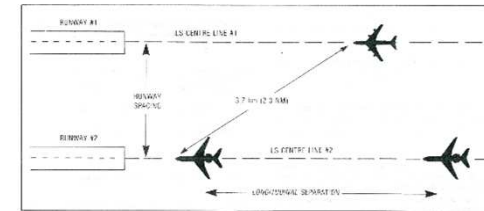
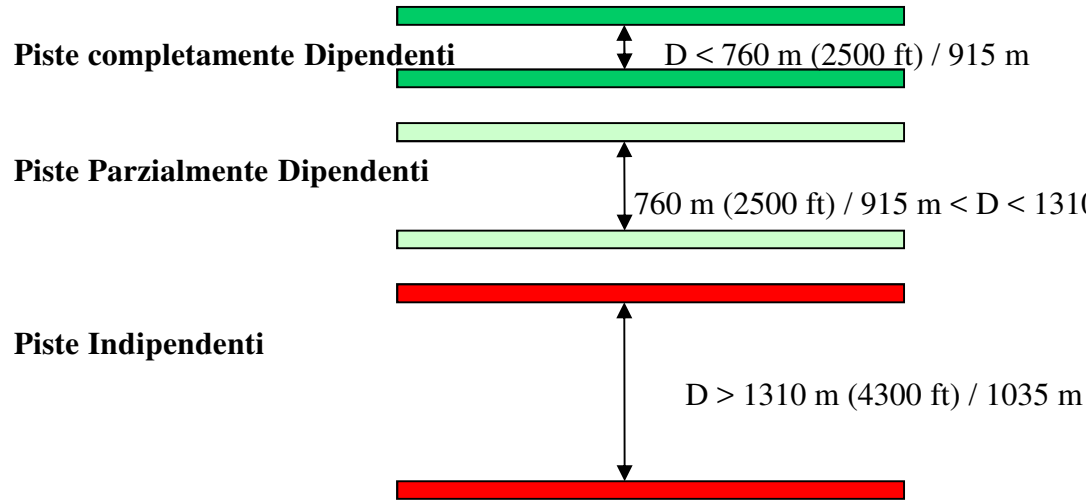
Codice numerico più alto delle piste: 2



Codice numerico più alto delle piste: 3 o 4

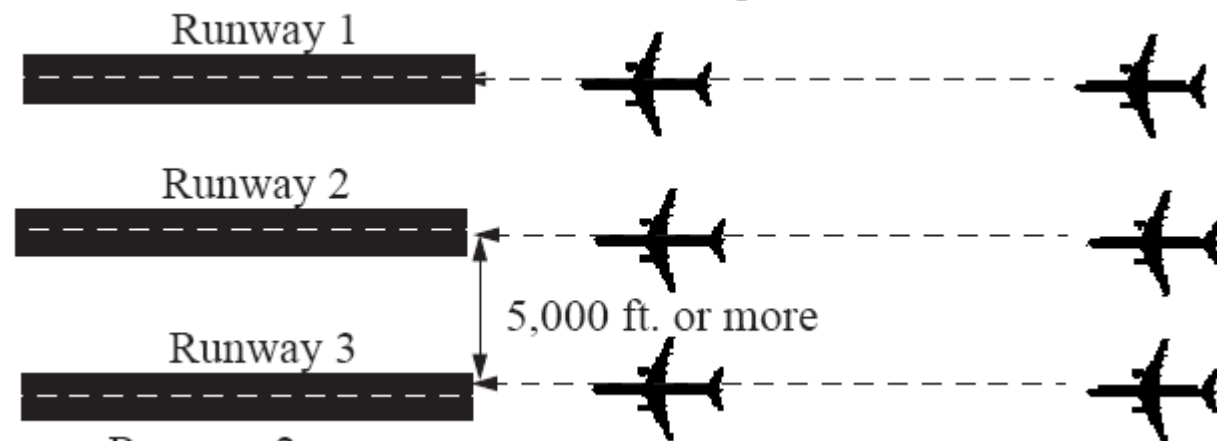
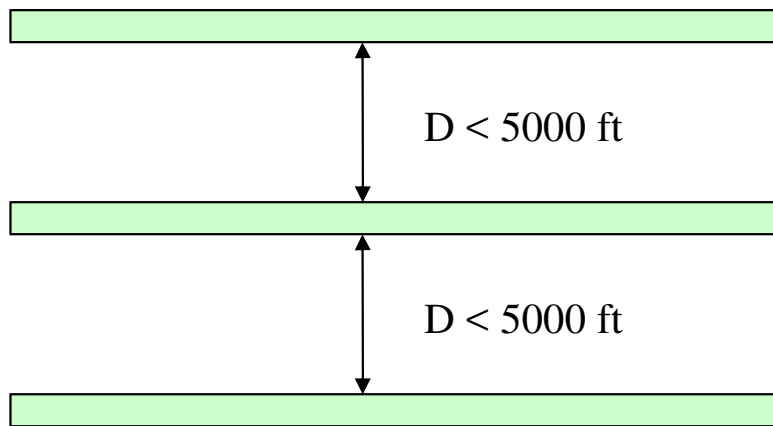


Separazione tra runway strumentali

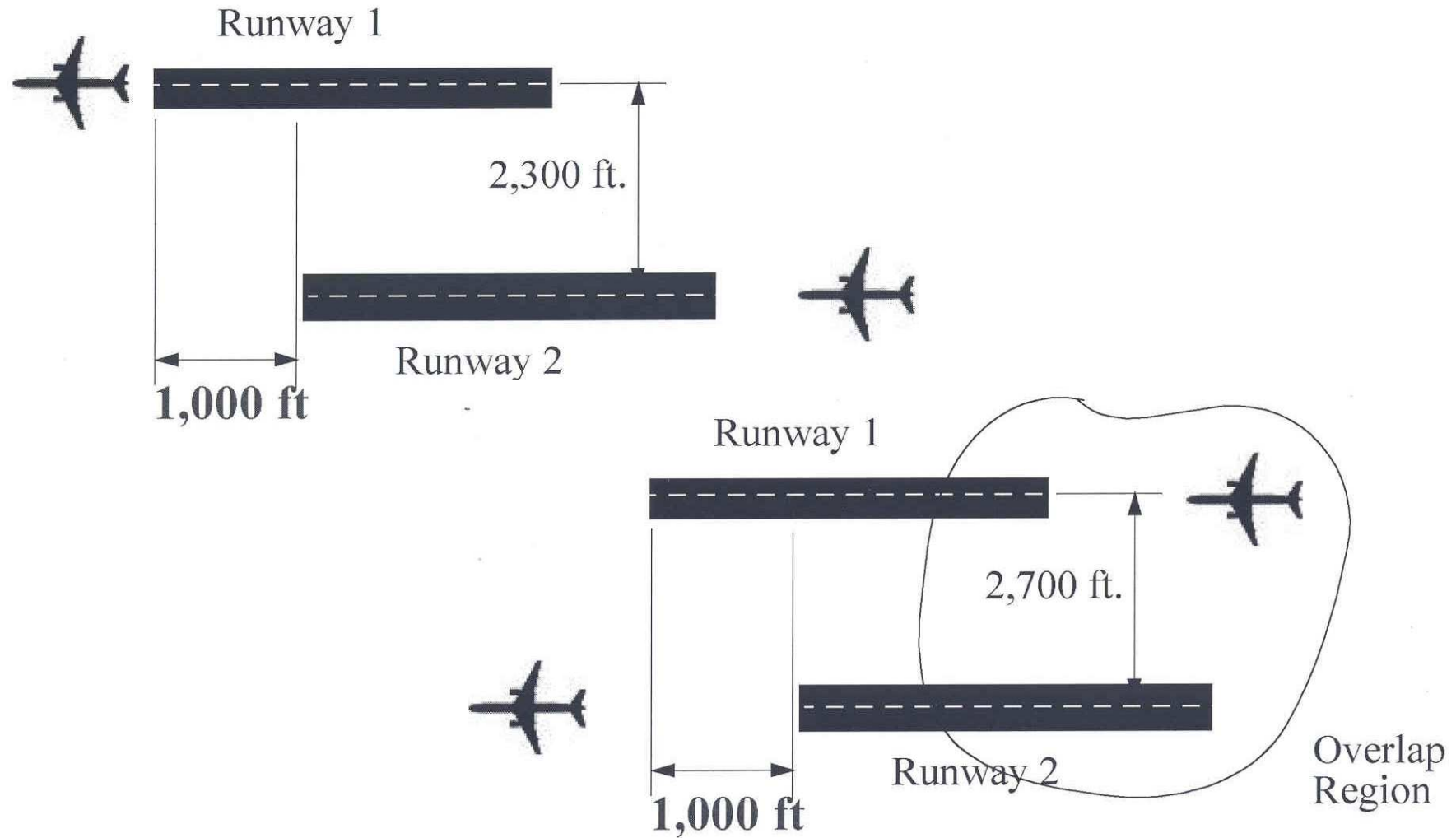


Situazione minime di indipendenza per partenze simultanee, operazioni segregate, atterraggi indipendenti

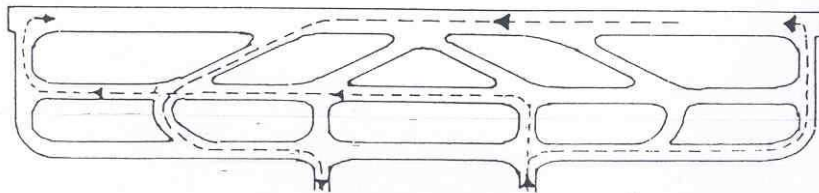
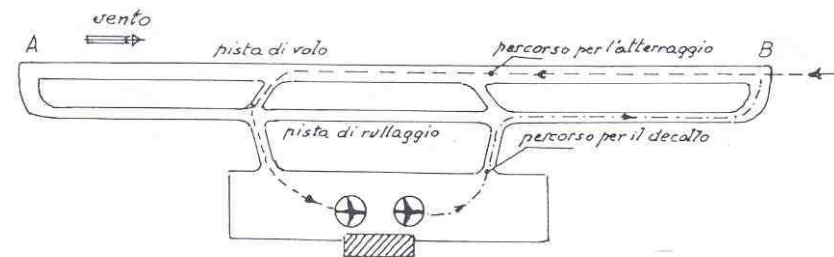
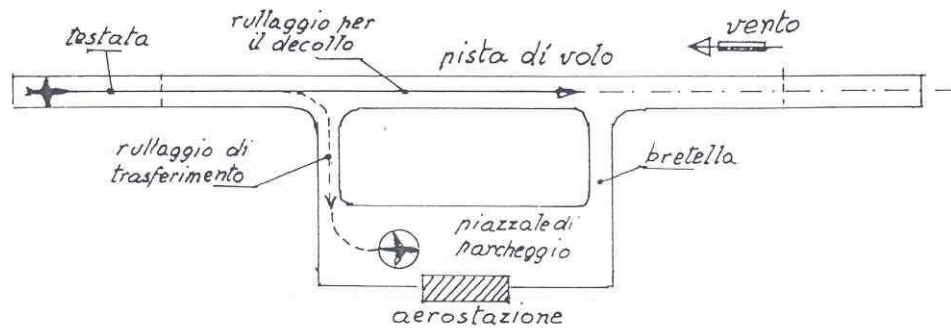
Separazione tra più runway strumentali



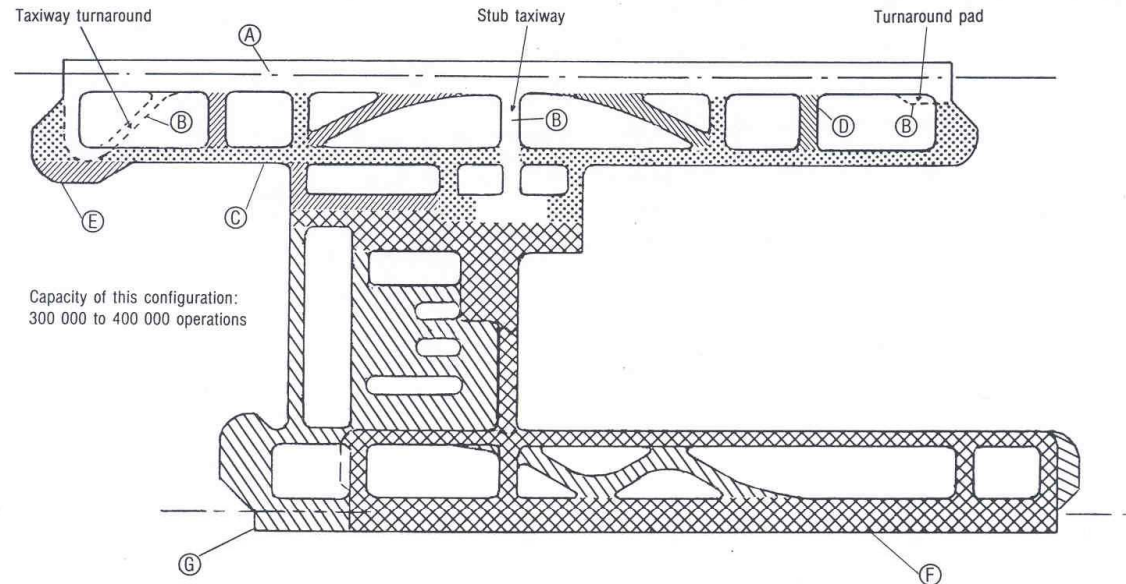
Runway sfalsate



Sistema delle Taxiway



Capacità e configurazione aeroportuale



ITEM	LOCATION OF CRITERIA
	SECTION
A	6.3.2
B	6.3.5 a)
C	6.3.5 b)
D	6.3.5 c)
E	6.3.5 d)
F	6.3.4 a) to c)
G	6.3.4 d)

LEVEL AT WHICH TO BUILD

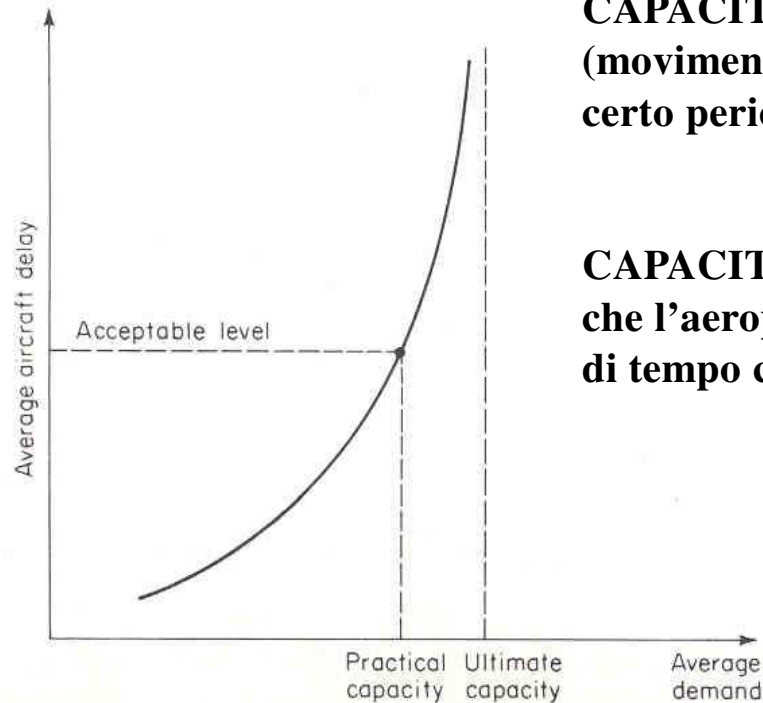
- Up to 20 000 to 30 000 operations
- 30 000 to 60 000 operations
- 50 000 to 99 000 operations
- 75 000 to 150 000 operations
- 150 000 to 250 000 operations

* The above ranges represent activity levels typical of values that would be obtained by use of these instructions. Although computed values would most likely fall in these ranges, this tabulation does not represent criteria.

Programmi di simulazione

Dominio Applicazione	Modello Macroscopico	Modello Microscopico
RUNWAY	-	REDIM, RUNSIM, LMI Run. Model, RDSIM
AIRSIDE	Airport Capacity Model DELAYS	SIMMOD, Airport Machine TAAM
AIRSPACE	SIMMOD NASPAC	SIMMOD, TAAM, RAMS
TERMINAL	APMSIM, ALDSIM	ALSIM
RUMORE	INM	SAIC Noise
INQUINAMENTO	EDMS	VPI plume Model

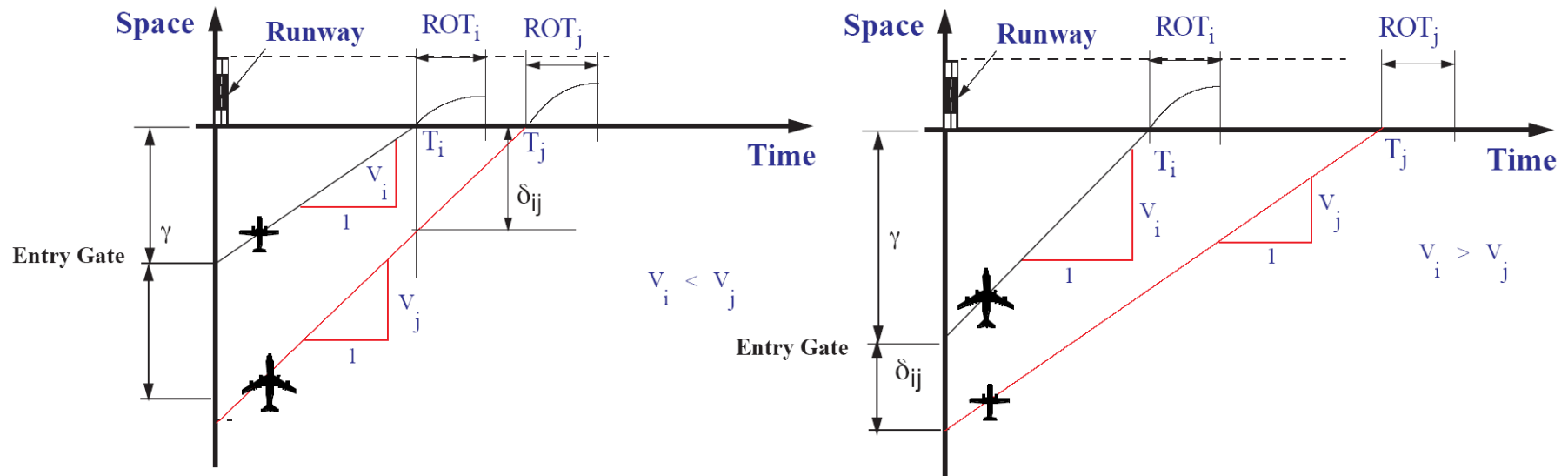
Definizioni di capacità



CAPACITÀ ULTIMA: è il numero massimo di operazioni (movimenti aerei) che l'aeroporto riesce a svolgere in un certo periodo di tempo.

CAPACITÀ PRATICA: è il numero massimo di operazioni che l'aeroporto riesce a svolgere in un determinato periodo di tempo con un determinato livello di servizio.

Capacità ultima



$$T_{ij} = \frac{\delta_{ij}}{V_j}$$

$$T_{ij} = \frac{\delta_{ij}}{V_j} + \gamma \left(\frac{1}{V_j} - \frac{1}{V_i} \right)$$

Calcolo Capacità ultima

$$T = \sum_{i,j} P_i \cdot P_j \cdot T_{ij} \quad \text{Esempio: } \gamma = 6 \text{ nm, } \delta = 3 \text{ nm}$$

$$C = \frac{1}{T}$$

Classe aereo	Percentuale	Velocità (nm/h)	ROT
1	0,20	100	50
2	0,20	120	60
3	0,60	135	70

$$T_{11} = \delta / V_1 = 3600 * 3/100 = 108 \text{ s}; T_{12} = 3600 * 3/120 = 90; T_{13} = 3600 * 3/135 = 80;$$

$$T_{21} = (\delta / V_1) + (\gamma / V_1) - (\gamma / V_2) = 3600 * (3/100 + 6/100 - 6/120) = 144 \text{ s}; T_{22} = 3600 * 3/120 = 90; T_{23} = 3600 * 3/135 = 80;$$

$$T_{31} = (\delta / V_1) + (\gamma / V_1) - (\gamma / V_3) = 3600 * (3/100 + 6/100 - 6/135) = 164 \text{ s};$$

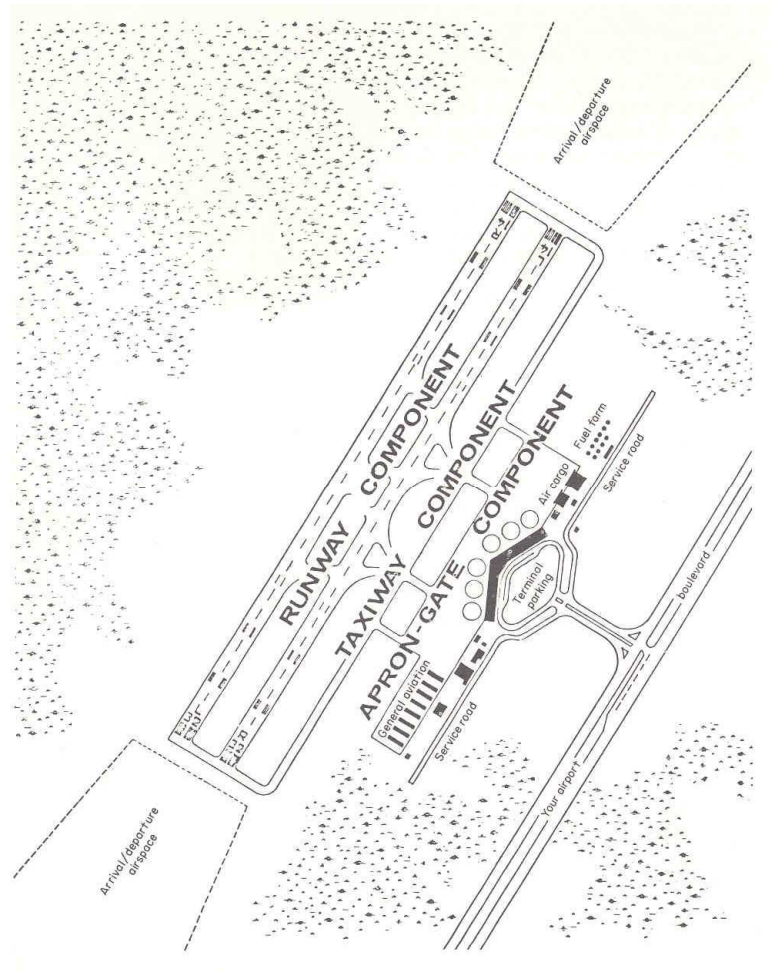
$$T_{32} = (\delta / V_2) + (\gamma / V_2) - (\gamma / V_3) = 3600 * (3/120 + 6/120 - 6/135) = 110 \text{ s};$$

$$T_{33} = 3600 * 3/135 = 80;$$

$$T = \sum_{i,j} P_i \cdot P_j \cdot T_{ij} = (0,20 \cdot 0,20 \cdot 108) + (0,20 \cdot 0,20 \cdot 90) + (0,60 \cdot 0,20 \cdot 80) + \dots = 98$$

$$C = 1/T = 3600 * 1/98 = 36 \text{ [arrivi/ora]}$$

Componenti del lato aria e capacità



Fattori da cui dipende la capacità

CONFIGURAZIONE D'USO DELLE RUNWAY

CONDIZIONI METEOROLOGICHE

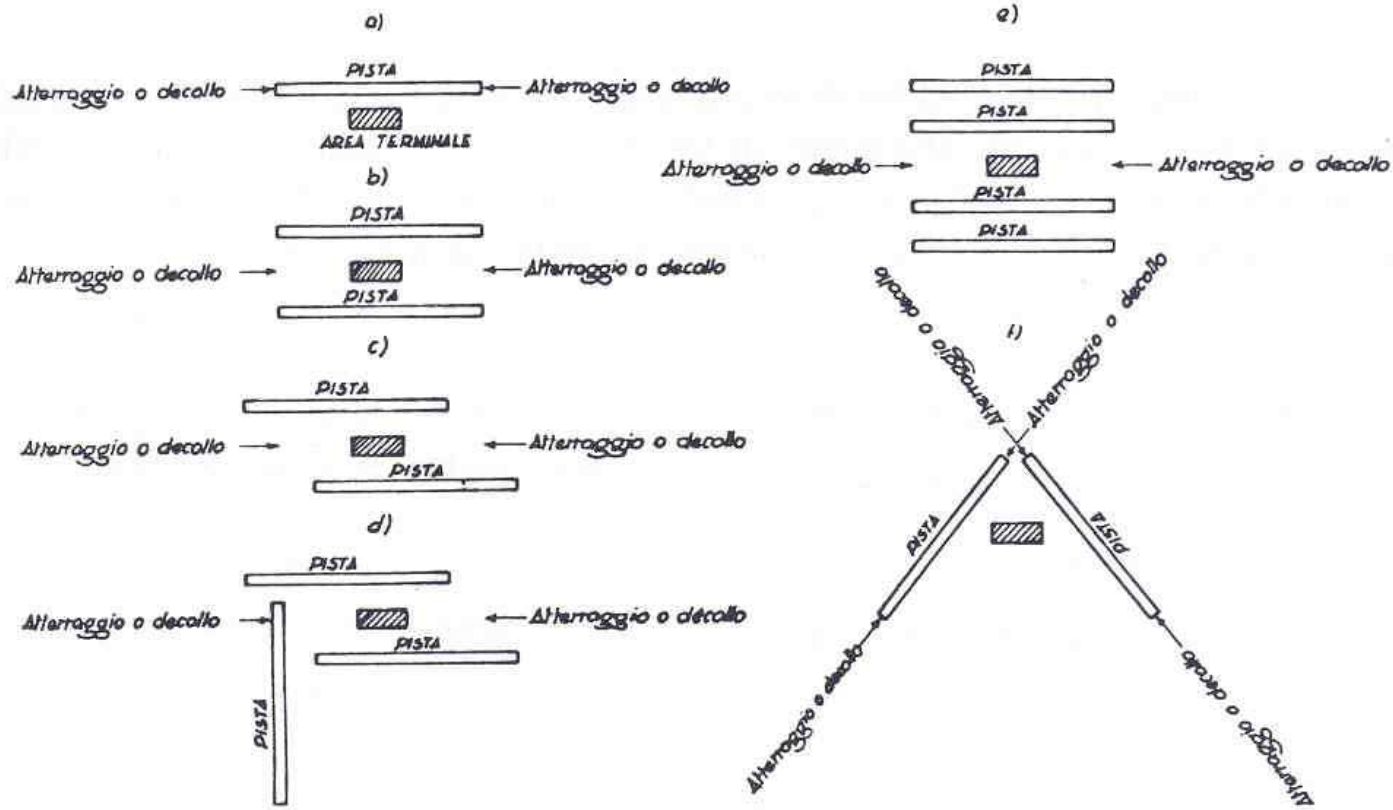
PIORITÀ DI TRAFFICO

COMPOSIZIONE DEL TRAFFICO AEREO

TEMPI DI SERVIZIO

INTERFERENZA CON AEROPORTI VICINI

Configurazione delle piste



Priorità di traffico

$$Pa = \frac{A + 0,5 \cdot (T \& G)}{A + DA + (T \& G)} \cdot 100$$

$$Ptg = \frac{(T \& G)}{A + DA + (T \& G)} \cdot 100$$

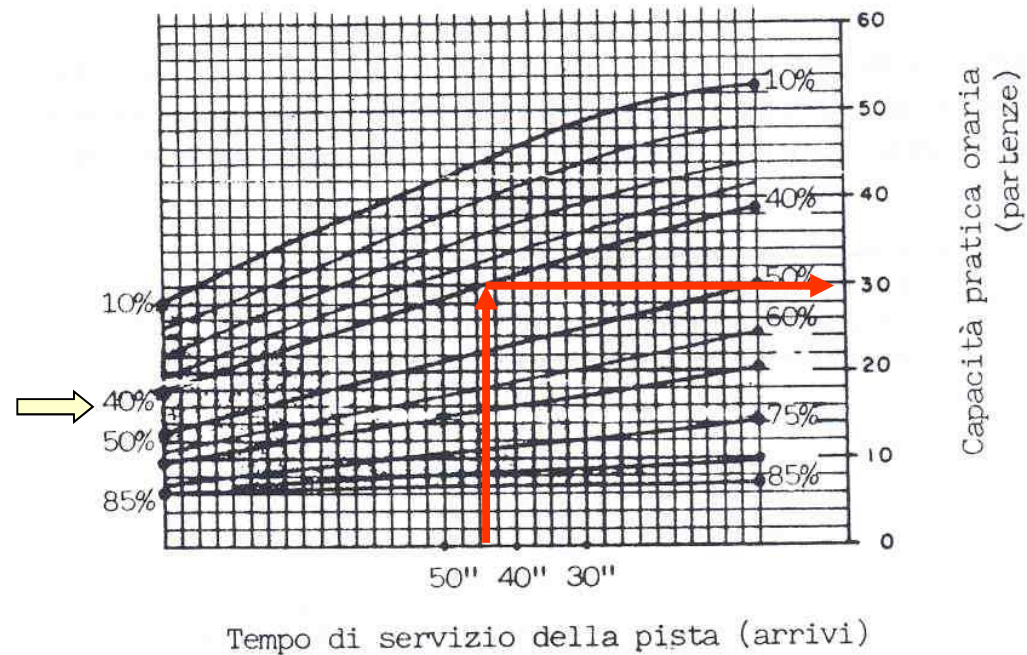
Pa = percentuale arrivi;

A = numero aerei in arrivo;

T&G = numero di operazioni Touch and Go (voli di addestramento)

DA = numero di partenze

Ptg = percentuale T&G

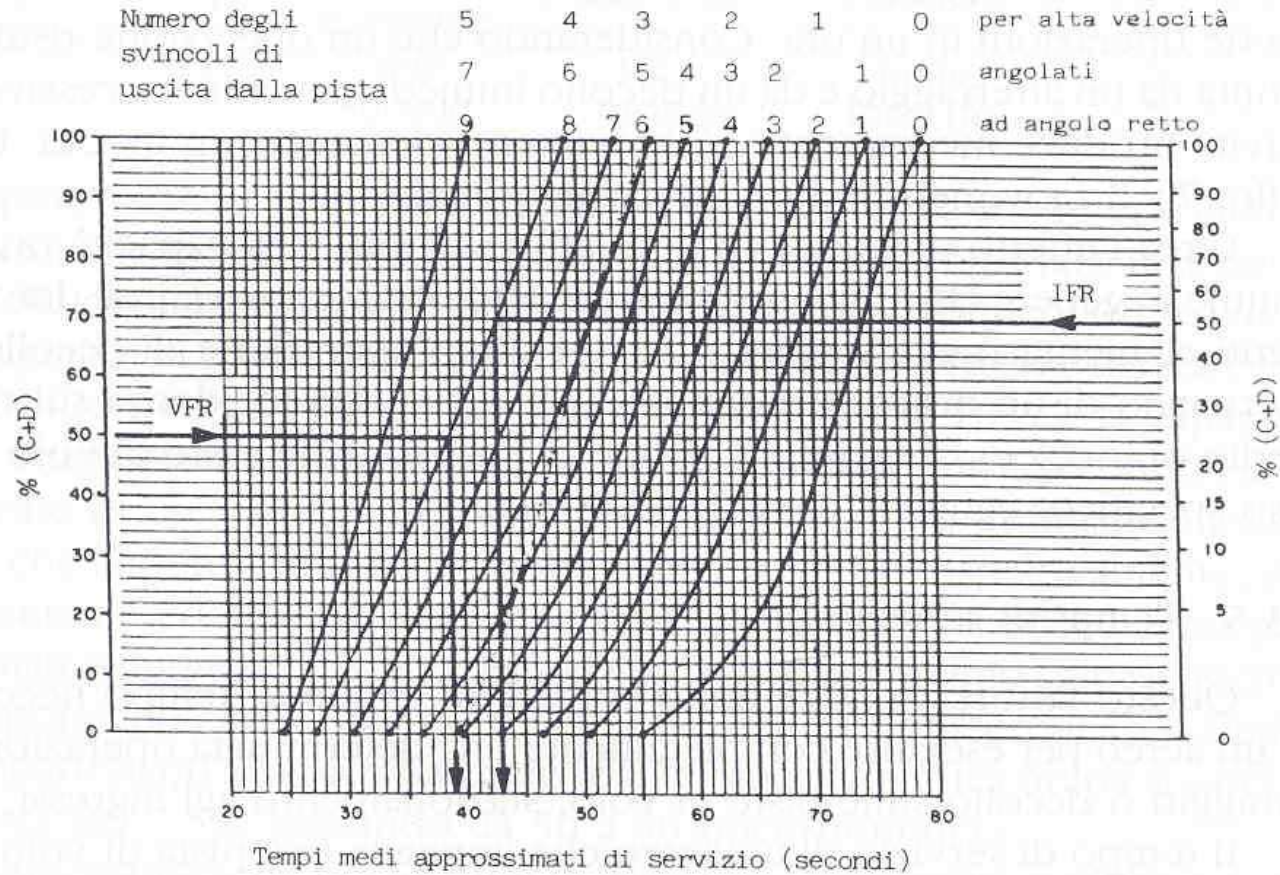


Composizione traffico aereo

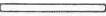
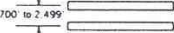

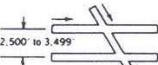
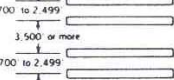

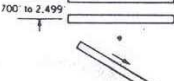
Aircraft Class	Max. Cert. T.O. Weight (lbs)	Number Engines	Wake Turbulence Classification
A	12,500 or less	Single	Small (S)
B		Multi	
C	12,500 - 300,000	Multi	Large (L)
D	over 300,000	Multi	Heavy (H)

Mix Index = % (C + 3 D) C e D percentuali aerei appartenenti alle classi C e D

Tempi di servizio



Capacità per pianificazioni (1)

Configuration	Runway Configuration Diagram	Mix Index— Percent (C + 3D)	Hourly Capacity (Operations per Hour)		Annual Service Volume (Operations per Year)
			VFR	IFR	
A Single Runway		0-20	98	59	230,000
		21-50	74	57	195,000
		51-80	63	56	205,000
		81-120	55	53	210,000
		121-180	51	50	240,000
B Dual Lane Runways		0-20	197	59	355,000
		21-50	145	57	275,000
		51-80	121	56	260,000
		81-120	105	59	285,000
		121-180	94	60	340,000
C Independent IFR Parallels		0-20	197	119	370,000
		21-50	149	114	320,000
		51-80	126	111	305,000
		81-120	111	105	315,000
		121-180	103	99	370,000
D Parallels plus Crosswind Runway		0-20	197	62	355,000
		21-50	149	63	285,000
		51-80	126	65	275,000
		81-120	111	70	300,000
		121-180	103	75	365,000
E Four Parallels		0-20	394	119	715,000
		21-50	290	114	550,000
		51-80	242	111	515,000
		81-120	210	117	565,000
		121-180	189	120	675,000
F Open V Runways		0-20	150	59	270,000
		21-50	108	57	225,000
		51-80	85	56	220,000
		81-120	77	59	225,000
		121-180	73	60	265,000
G Parallels plus Crosswind Runway		0-20	295	59	385,000
		21-50	210	57	305,000
		51-80	164	56	275,000
		81-120	146	59	300,000
		121-180	129	60	355,000

Capacità per pianificazioni (2)

No.	Runway-use Configuration	Mix Index %(C+3D)	Hourly Capacity Ops/Hr		Annual Service Volume Ops/Yr	Runway-use Configuration	Mix Index %(C+3D)	Hourly Capacity Ops/Hr		Annual Service Volume Ops/Yr
			VFR	IFR				VFR	IFR	
1.		0 to 20	98	59	230,000		0 to 20	295	62	385,000
		21 to 50	74	57	195,000		21 to 50	219	63	310,000
		51 to 80	63	56	205,000		51 to 80	184	65	290,000
		81 to 120	55	53	210,000		81 to 120	161	70	315,000
		121 to 180	51	50	240,000		121 to 180	146	75	385,000
2.		0 to 20	197	59	355,000		0 to 20	295	119	625,000
		21 to 50	145	57	275,000		21 to 50	219	114	475,000
		51 to 80	121	56	260,000		51 to 80	184	111	455,000
		81 to 120	105	59	285,000		81 to 120	161	117	510,000
		121 to 180	94	60	340,000		121 to 180	146	120	645,000
3.		0 to 20	197	62	355,000		0 to 20	394	119	715,000
		21 to 50	149	63	285,000		21 to 50	290	114	550,000
		51 to 80	126	65	275,000		51 to 80	242	111	515,000
		81 to 120	111	70	300,000		81 to 120	210	117	565,000
		121 to 180	103	75	365,000		121 to 180	189	120	675,000
4.		0 to 20	197	119	370,000		0 to 20	98	59	230,000
		21 to 50	149	113	320,000		21 to 50	77	57	200,000
		51 to 80	126	111	305,000		51 to 80	77	56	215,000
		81 to 120	111	105	315,000		81 to 120	76	59	225,000
		121 to 180	103	99	370,000		121 to 180	72	60	265,000
5.		0 to 20	295	62	385,000		0 to 20	197	59	355,000
		21 to 50	213	63	305,000		21 to 50	145	57	275,000
		51 to 80	171	65	285,000		51 to 80	121	56	260,000
		81 to 120	149	70	310,000		81 to 120	105	59	285,000
		121 to 180	129	75	375,000		121 to 180	94	60	340,000

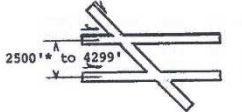
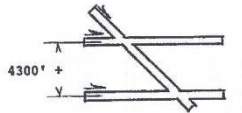
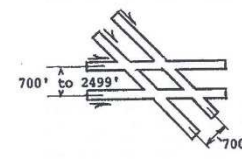
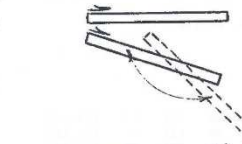
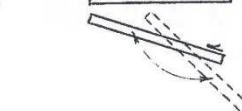
* Staggered threshold adjustments may apply, see paragraph 4-6.

Figure 2-1. Capacity and ASV for long range planning

* Staggered threshold adjustments may apply, see paragraph 4-6.

Figure 2-1. Capacity and ASV for long range planning (cont.)

Capacità per pianificazioni (3)

No.	Runway-use Configuration	Mix Index %(C+3D)	Hourly Capacity Ops/Hr		Annual Service Volume Ops/Yr
			VFR	IFR	
11.		0 to 20	197	62	355,000
		21 to 50	149	63	285,000
		51 to 80	126	65	275,000
		81 to 120	111	70	300,000
		121 to 180	103	75	365,000
12.		0 to 20	197	119	370,000
		21 to 50	149	114	320,000
		51 to 80	126	111	305,000
		81 to 120	111	105	315,000
		121 to 180	103	99	370,000
13.		0 to 20	197	59	355,000
		21 to 50	147	57	275,000
		51 to 80	145	56	270,000
		81 to 120	138	59	295,000
		121 to 180	125	60	350,000
14.		0 to 20	150	59	270,000
		21 to 50	108	57	225,000
		51 to 80	85	56	220,000
		81 to 120	77	59	225,000
		121 to 180	73	60	265,000
15.		0 to 20	132	59	260,000
		21 to 50	99	57	220,000
		51 to 80	82	56	215,000
		81 to 120	77	59	225,000
		121 to 180	73	60	265,000

*Staggered threshold adjustments may apply, see paragraph 4-6.

Figure 2-1. Capacity and ASV for long range planning (cont.)

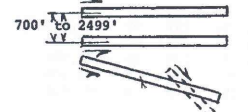
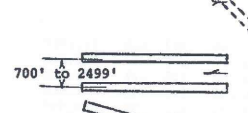

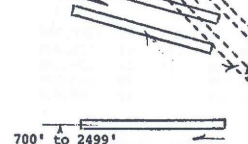
No.	Runway-use Configuration	Mix Index %(C+3D)	Hourly Capacity Ops/Hr		Annual Service Volume Ops/Yr
			VFR	IFR	
5.		0 to 20	295	59	385,000
		21 to 50	210	57	305,000
		51 to 80	164	56	275,000
		81 to 120	146	59	300,000
		121 to 180	129	60	355,000
7.		0 to 20	197	59	355,000
		21 to 50	145	57	275,000
		51 to 80	121	56	260,000
		81 to 120	105	59	285,000
		121 to 180	94	60	340,000
8.		0 to 20	301	59	385,000
		21 to 50	210	57	305,000
		51 to 80	164	56	275,000
		81 to 120	146	59	300,000
		121 to 180	129	60	355,000
9.		0 to 20	264	59	375,000
		21 to 50	193	57	295,000
		51 to 80	158	56	275,000
		81 to 120	146	59	300,000
		121 to 180	129	60	355,000

Figure 2-1. Capacity and ASV for long range planning (cont.)

Ipotesi per pianificazioni

Mix Index %(C+3D)	Percent Arrivals	Percent Touch & Go	Demand Ratios	
			Annual Demand Av. Daily Demand*	Av. Daily Demand* Av. Peak Hour Demand*
0-20	50	0-50	290	9
21-50	"	0-40	300	10
51-80	"	0-20	310	11
81-120	"	0	320	12
121-180	"	0	350	14

* In the peak month

Per la valutazione della capacità oraria:

Taxiways presenti per tutta la lunghezza delle piste;

Nessuna limitazione dello spazio aereo;

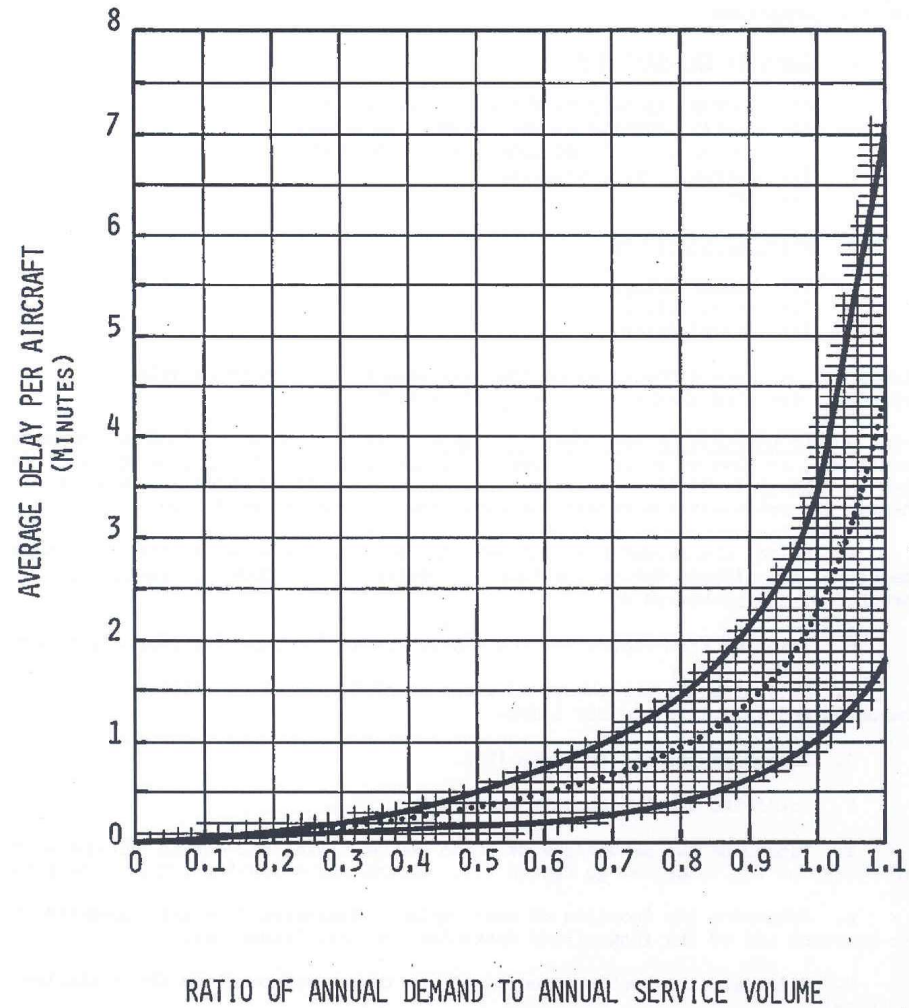
Almeno una pista strumentale e dotazione del radar

Per la valutazione del volume annuale:

Solo il 10 % del tempo si hanno situazioni di tempo di IFR

80 % del tempo l'aeroporto lavora alla massima capacità oraria

Ritardi per pianificazioni



Esempio (1)

DATI:

aeroporto con 1 runway;

domanda di 220.000 operazioni/anno;

41% Aerei Small (metà con un motore), 55 % large, 4 % heavy.

Calcolare la capacità esistente;

identificare le modifiche per soddisfare la domanda;

determinare il ritardo annuale.

EXAMPLE 1. Determine whether the runway capacity is adequate to accommodate the forecasted demand.

SOLUTION:

1. **Aircraft Mix.** Enter the mix of the forecasted demand (41% small, 55% large, 4% heavy) in columns 1 through 4 of the work sheet.

Table 1-1. Aircraft classifications

Aircraft Class	Max. Crnt. T.O. Weight (lbs)	Number Engines	Wake Turbulence Classification
A	12,500 or less	Single	Small (S)
B		Multi	
C	12,500 - 300,000	Multi	Large (L)
D	over 300,000	Multi	Heavy (H)

2. **Runway-use.** Select the runway-use configuration from figure 2-1 that best represents the airport. Enter the diagram number (1) in column 6 and a line sketch of the configuration in column 7.

No.	Runway-use Configuration	Mix Index %(C+3D)	Hourly Capacity Ops/Hr		Annual Service Volume Ops/Yr
			VFR	IFR	
1.		0 to 20	98	59	230,000
		21 to 50	74	57	195,000
		51 to 80	63	56	205,000
		81 to 120	55	53	210,000
		121 to 180	51	50	240,000

3. **Mix Index.** Calculate the mix index, $55+3(4) = 67$, and enter in column 5.

4. **Hourly Capacity.** Enter the hourly VFR and IFR capacities and the ASV, obtained from diagram 1, figure 2-1, in columns 8, 9, and 10.

Aircraft Mix				Mix Index %(C+3D)	Configuration		Capacity (Ops/Hour) (000)		ASV (000)	Annual Demand (000)	Annual Demand ASV	Average Delay per Aircraft Annual Delay (Minutes)		Minutes of Annual Delay (000)	
%A	%B	%C	%D		No.	Sketch	VFR	IFR				Low	High	Low	High
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
21	20	55	4	67	1		63	56	205						

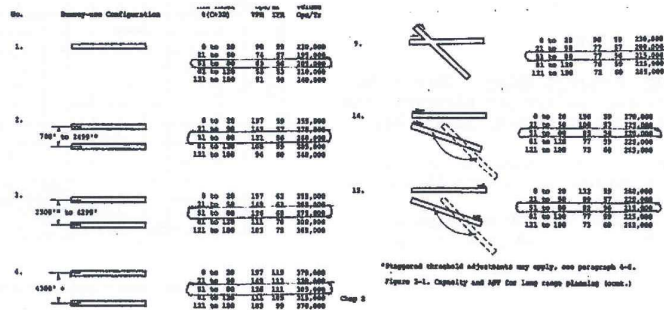
5. **Conclusion.** The ASV of 205,000 operations is less than the forecasted demand of 220,000 annual operations. Unless additional capacity is provided, delays will become costly.

Esempio (2)

EXAMPLE 2. Example 1 concluded that the ASV of 205,000 operations is less than the forecasted 220,000 operational demand. Identify alternative two-runway configurations that will accommodate the demand.

SOLUTION:

1. **Capacity of Alternatives.** Repeat each of the calculations of example 1 for each of the two-runway configurations.



*Planned threshold adjustments may apply, see paragraph 6-4. Figure 3-1. Capacity and ASV for long range planning form.

Aircraft Mix				Mix Index	Configuration	Capacity (Ops/Hour)		ASV (000)	Annual Demand (000)	Annual Demand ASV	Average Delay per Aircraft (Minutes)		Minutes of Annual Delay (000)	
1A	1B	1C	1D	1(C+D)		VFR	IFR				Low	High	Low	High
21	20	55	4	67	1	63	56	205						
"	"	"	"	"	2	121	56	260						
"	"	"	"	"	3	126	65	273						
"	"	"	"	"	4	126	111	305						
"	"	"	"	"	9	77	56	215						
"	"	"	"	"	14	85	56	220						
"	"	"	"	"	15	82	56	215						

2. **Conclusion.** The parallel runway-use configuration (4), which meets the separation requirements for simultaneous instrument approaches, provides the best VFR and IFR hourly capacities and ASV. Any of the parallel runway-use configurations as well as the diverging runway-use configuration meet the forecasted demand. The crossing and converging runway-use configurations have less capacity than the forecasted demand.

EXAMPLE 3. What annual delay is anticipated for the existing and each of the alternative runway-use configurations?

SOLUTION: The following calculations are for the existing single runway-use configuration are repeated for each of the alternative runway-use configurations.

1. **Annual Demand.** Enter 220,000 (operations) in column 11.

2. **Demand-ASV Ratios.** Divide the annual demand by the ASV and enter in column 12.

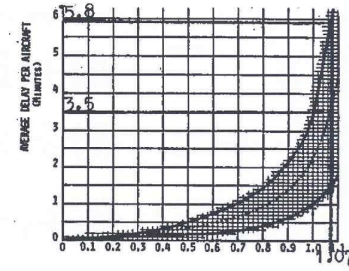
$$220/205 = 1.07$$

3. **Average Aircraft Delay.** Obtain the high and low average delays per aircraft from figure 2-2 and enter in columns 13 and 14.

4. **Annual Delay.** Calculate annual delay and enter results in columns 15 and 16.

$$3.5 \times 220,000 = 770,000 \text{ minutes}$$

$$5.8 \times 220,000 = 1,276,000 \text{ minutes}$$



Ratio of Annual Demand to Annual Service Volume

Figure 2-2. Average aircraft delay for long range planning

Aircraft Mix				Mix Index	Configuration	Capacity (Ops/Hour)		ASV (000)	Annual Demand (000)	Annual Demand ASV	Average Delay per Aircraft (Minutes)		Minutes of Annual Delay (000)	
1A	1B	1C	1D	1(C+D)		VFR	IFR				Low	High	Low	High
21	20	55	4	67	1	63	56	205	220	1.07	3.5	5.8	770	1276
"	"	"	"	"	2	121	56	260	"	.85	1.15	1.8	253	396
"	"	"	"	"	3	126	65	273	"	.80	.95	1.45	209	319
"	"	"	"	"	4	126	111	305	"	.72	.7	1.1	154	242
"	"	"	"	"	9	77	56	215	"	1.02	2.6	4.0	572	880
"	"	"	"	"	14	85	56	220	"	1.0	2.3	3.4	506	748
"	"	"	"	"	15	82	56	215	"	1.02	2.6	4.0	572	880

5. **Conclusions.** Average delay per aircraft and annual delay with parallel runway-use configurations are significantly less than with any of the other runway-use configurations.

Calcolo capacità oraria Runway (1)

Diagram	Diag. No.	Runway Spacing in Feet (S)	Figure No.			
			For Capacity		For Delay	
			VFR	IFR	VFR	IFR
	1	NA	3-4	3-7	3-1	3-30
	2	700 or more	3-4	3-44	3-7	3-31
	3	700 to 2499	3-5	3-48	3-73	3-31
	4	2500 or more	3-5	3-45	3-74	3-32
	5*	700 to 2499	3-7	3-44	3-75	3-31
	6	2500 to 2999	3-8	3-45	3-75	3-33
	7	3000 to 4299	3-8	3-47	3-75	3-33
	8	4300 or more	3-8	3-48	3-75	3-34
	9*	700 to 2499	3-9	3-44	3-71	3-31
	10	2500 to 2999	3-10	3-49	3-71	3-35
	11	3000 to 4299	3-10	3-50	3-71	3-35
	12	4300 or more	3-10	3-51	3-71	3-35
	13*	700 to 2499	3-11	3-52	3-76	3-37
	14	2500 to 2999	3-11	3-53	3-76	3-37
	15	3000 or more	3-11	3-54	3-76	3-38
	16	700 to 2499	3-12	3-52	3-77	3-37
	17	2500 to 2999	3-13	3-53	3-78	3-37
	18	3000 or more	3-13	3-55	3-78	3-39
	19	700 to 2499	3-14	3-55	3-78	3-100
	20	2500 to 2999	3-13	3-49	3-78	3-35
	21	3000 to 4299	3-13	3-53	3-78	3-35
	22	4300 or more	3-13	3-55	3-78	3-39
	23*	700 or more	3-14	3-56	3-78	3-100
	24*	700 to 2499	3-15	3-52	3-79	3-37
	25	2500 to 2999	3-16	3-53	3-80	3-35
	26	3000 or more	3-16	3-55	3-80	3-39
	27*	700 to 2499	3-15	3-52	3-79	3-37
	28	3000 or more	3-17	3-54	3-80	3-38
	29*	700 to 2499	3-18	3-49	3-81	3-35
	30	2500 to 2999	3-19	3-53	3-71	3-35
	31	3000 or more	3-19	3-55	3-71	3-39
	32	3000 or more	3-20	3-58	3-72	3-31
	33	3000 or more	3-20	3-58	3-72	3-31
	34	3000 or more	3-21	3-58	3-82	3-31

Runway-use Diagram	Diag. No.	Runway Spacing in Feet (S)	Figure No.			
			For Capacity		For Delay	
			VFR	IFR	VFR	IFR
	35	3000 or more	-21	3-58	3-82	3-31
	36*	3000 to 4299	3-22	3-55	3-83	3-39
	37	4300 or more	3-22	3-58	3-83	3-31
	38*	3000 or more	3-22	3-58	3-83	3-31
	39*	3000 or more	3-23	3-58	3-84	3-31
	40*	3000 or more	3-24	3-58	3-84	3-31
	41*	3000 or more	3-25	3-58	3-80	3-31
	42*	3000 or more	3-26	3-58	3-71	3-31

LEGEND

INDICATES THAT AN ARRIVAL (LANDING) CAN OCCUR ON THE RUNWAY INDICATED.
 INDICATES THAT A DEPARTURE (TAKEOFF) CAN OCCUR ON THE RUNWAY INDICATED.
 THE LACK OF A SYMBOL MEANS THAT AIRCRAFT OPERATIONS WILL NOT OCCUR ON THE RUNWAY INDICATED.

S INDICATES A VARIABLE RUNWAY SPACING.
 C INDICATES A RUNWAY SPACING OF 700 TO 2499 FEET.
 S, V INDICATES INTERSECTION DISTANCES.
 D INDICATES THE ANGLE BETWEEN NONPARALLEL RUNWAYS.
 N.A. MEANS NOT APPLICABLE.
 < INDICATES "LESS THAN".
 > INDICATES "GREATER THAN OR EQUAL TO".
 FOR THOSE CASES IN WHICH THE MAJORITY OF AIRCRAFT ARE RESTRICTED FROM USING ONE, OR MORE, OF THE RUNWAYS, SEE CHAPTER 4.

Runway-use Diagram	Diag. No.	Runway Intersection Distance in Feet (X) (Y)	Figure No.			
			For Capacity		For Delay	
			VFR	IFR	VFR	IFR
	43	0 to 1999	< 4000	3-27	3-59	3-85
	44	2000 to 4999	< 4000	3-28	3-60	3-85
	45	5000 to 8000	< 4000	3-29	3-61	3-85
	46	0 to 1999	> 4000	3-30	3-62	3-85
	47	2000 to 4999	> 4000	3-31	3-63	3-71
	48	5000 to 8000	> 4000	3-32	3-64	3-102
	49	0 to 1999	< 4000	3-27	3-59	3-85
	50	2000 to 4999	< 4000	3-28	3-60	3-85
	51	5000 to 8000	< 4000	3-29	3-61	3-85
	52	0 to 1999	> 4000	3-30	3-62	3-85
	53	2000 to 4999	> 4000	3-31	3-63	3-71
	54	5000 to 8000	> 4000	3-3	3-63	3-71
	55*	0 to 1999	< 4000	3-33	3-59	3-85
	56*	2000 to 4999	< 4000	3-34	3-60	3-85
	57*	5000 to 8000	< 4000	3-35	3-61	3-85
	58*	0 to 1999	> 4000	3-36	3-62	3-85
	59*	2000 to 4999	> 4000	3-37	3-63	3-87
	60*	5000 to 8000	> 4000	3-38	3-64	3-102
	61*	0 to 1999	< 4000	3-33	3-59	3-85
	62*	2000 to 4999	< 4000	3-39	3-64	3-85
	63*	5000 to 8000	< 4000	3-35	3-64	3-85
	64*	0 to 1999	> 4000	3-36	3-64	3-85
	65*	2000 to 4999	> 4000	3-37	3-64	3-87
	66*	5000 to 8000	> 4000	3-3	3-64	3-71

Runway-use Diagram	Diag. No.	Runway Spacing in Feet (S)	Figure No.			
			For Capacity		For Delay	
			VFR	IFR	VFR	IFR
	67*	700 or more	3-4	3-44	3-72	3-31
	68*	700 to 2499	3-9	3-44	3-71	3-31
	69	2500 to 2999	3-10	3-49	3-71	3-35
	70	3000 to 4299	3-10	3-50	3-71	3-35
	71	4300 or more	3-10	3-51	3-71	3-35

Runway-use Diagram	Diag. No.	Angle θ	Figure No.			
			For Capacity		For Delay	
			VFR	IFR	VFR	IFR
	72	NA	3-4	3-44	3-72	3-31
	73	NA	3-4	3-44	3-72	3-31

Calcolo capacità oraria Runway (2)

9/23/83

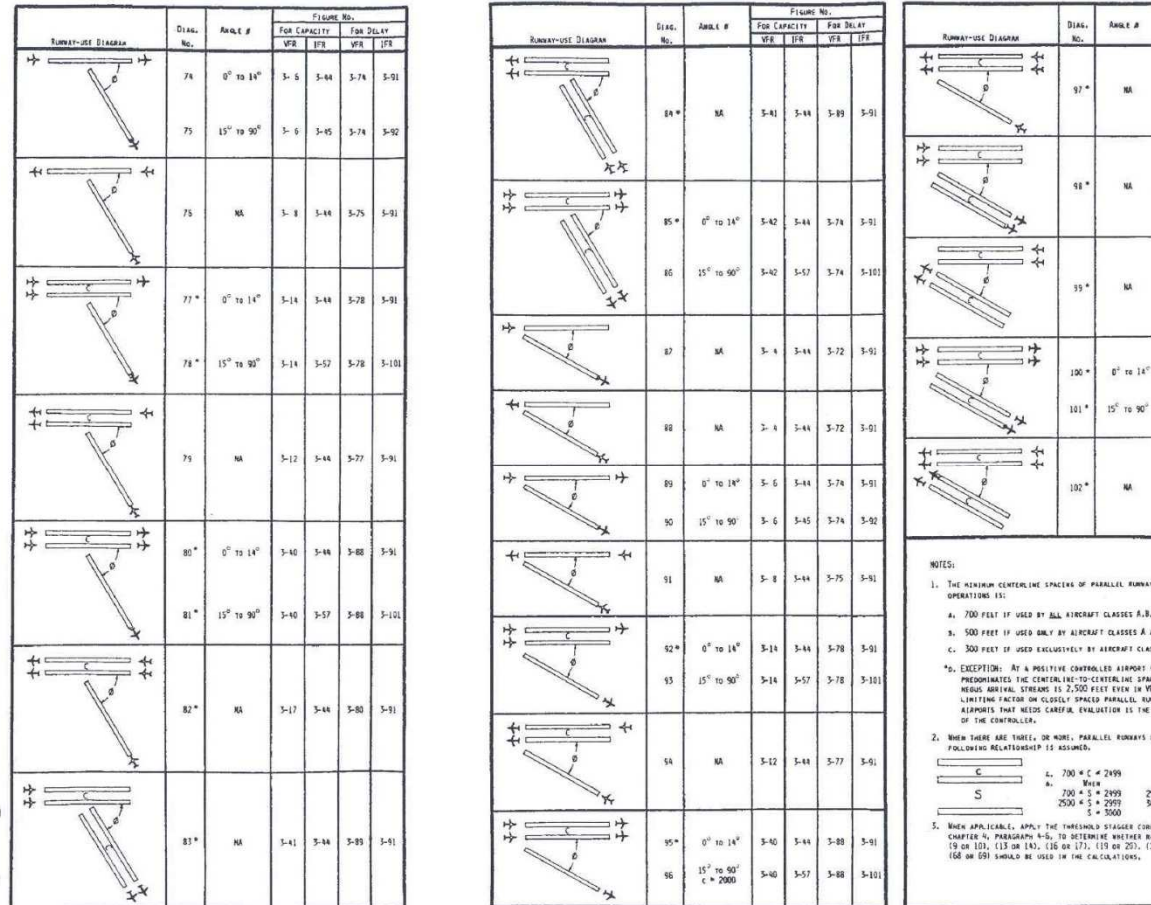
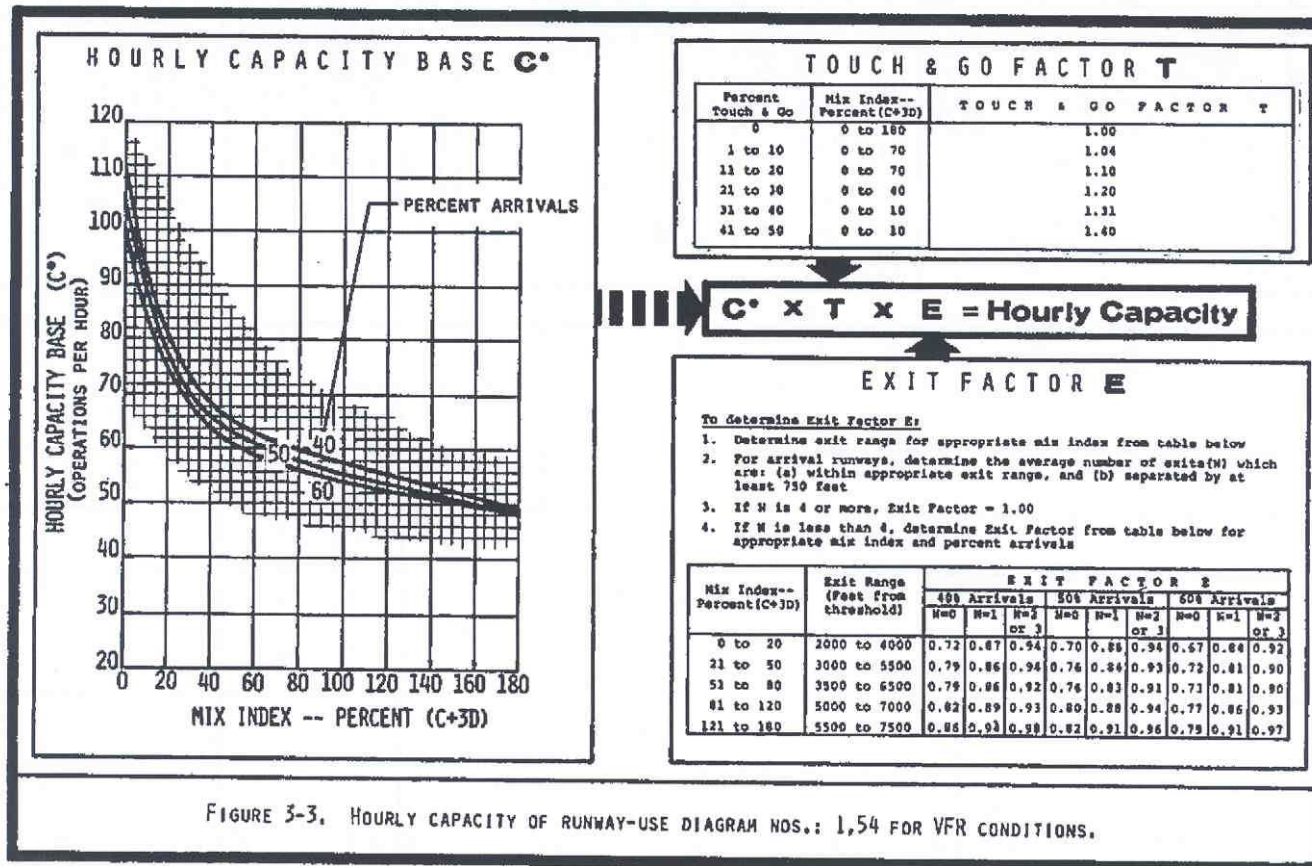
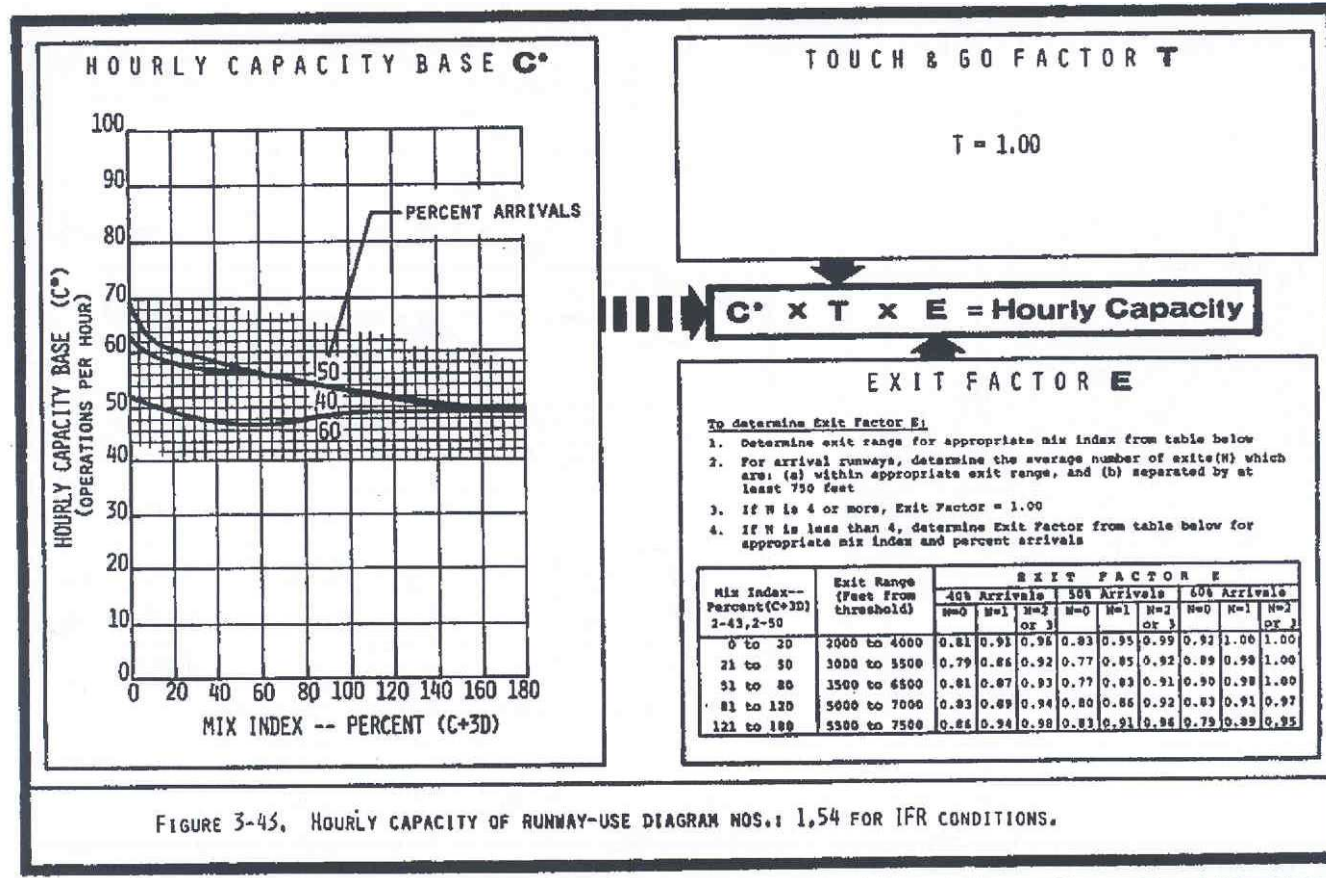


Figure 3-2. Runway-use diagrams

Calcolo capacità oraria Runway (3)

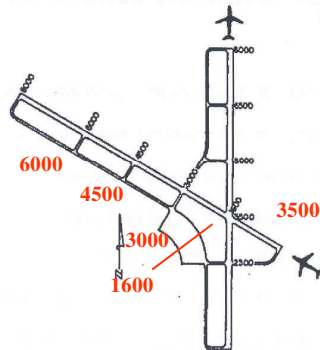


Calcolo capacità oraria Runway (4)



Calcolo capacità oraria Runway (5)

EXAMPLE 1. Determine VFR and IFR hourly capacities of the depicted airport. In the typical busy hour, it has 13 single-engine, 10 light twin-engine, 25 transport type, and two widebody operations. During VFR conditions, arrivals constitute 45 percent of the operations and there are three touch and go's. During IFR conditions, the busy hour count of small aircraft operations drops to two single-engine and five light twin-engine aircraft and arrivals constitute 55 percent of the operations. There are no touch and go's during IFR conditions. The airport typically operates with arrivals on one runway and departures on the other.



SOLUTION: The work sheet on page 5 illustrates one method of recording data.

- Weather.** Enter the weather condition(s) applicable to the capacity determination in column 1.
- Runway-use.** From figure 3-2 (illustrated), the runway-use configuration diagram is No. 43. Enter this diagram number in column 3, and a line sketch of the configuration in column 2.
- Capacity Figure(s).** The appropriate figures for determining capacity are No. 3-27 for VFR conditions and No. 3-59 for IFR conditions. These VFR and IFR references are entered on the line in column 4 corresponding to the weather condition.

Weather	Runway-use		Capacity Figure No.	Aircraft Mix						Percent Arrivals	Percent Touch & Go	Runway Exits (50 feet)			Hourly Capac. Base	P & G Factor	Exit Factor	Hourly Capacity (000)
	Diagram	No.		1	2	3	4	5	6			7	8	9				
VFR	[Sketch of Runway 43]	43	3-27	26	20	50	4	62	45	12	45	60	2	89	1.06	.94	89	
IFR			3-59	6	15	73	6	91	55	0	60		1	53	1.00	.97	51	

Work sheet for runway hourly capacity.

Runway-use Diagram	Diagram No.	Runway Intersection		Figure No.			
		Distance in Feet		For Capacity		For Delay	
		(a)	(b)	VFR	IFR	VFR	IFR
[Diagram 43]	43	0 to 1999	= 4000	3-27	3-59	3-85	3-91
	44	2000 to 4999	= 4000	3-28	3-60	3-86	3-98
	45	5000 to 8000	= 4000	3-29	3-61	3-86	3-99
	46	0 to 1999	= 4000	3-30	3-62	3-86	3-99
	47	2000 to 4999	= 4000	3-31	3-63	3-71	3-102
	48	5000 to 8000	= 4000	3-32	3-64	3-71	3-102
	49	0 to 1999	= 4000	3-33	3-65	3-71	3-102

Calcolo capacità oraria Runway (6)

4. Mix Index. This input is calculated using data provided in the example statement. Table 1-1 (illustrated) is used to make the conversion.

Table 1-1. Aircraft classifications

Aircraft Class	Max. Cert. T.O. Weight (lbs)	Number Engines	Wake Turbulence Classification
A	12,500 or less	Single	Small (S)
B		Multi	
C	12,500 - 300,000	Multi	Large (L)
D	over 300,000	Multi	Heavy (H)

The computation of aircraft mix is carried out by setting up a table in the following format. The percent of operations by each aircraft class is recorded in columns 5 through 8.

Aircraft		VFR Mix		IFR Mix	
Description	Class	No. Ops.	% Ops.	No. Ops.	% Ops.
Single-engined	A	13	26	2	6
Light-twins	B	10	20	5	15
Transport-type	C	25	50	25	73
Widebodied	D	2	4	2	6
Totals (No. Ops. & % Ops.)		50	100	34	100

The mix indices are calculated and entered in column 9.

$$\text{VFR} = 50 + 3(4) = 62 \quad \%C + 3 * \%D$$

$$\text{IFR} = 73 + 3(6) = 91$$

5. Percent Arrivals. The percent arrivals is given as 45 for VFR conditions and 55 for IFR conditions. Enter in column 10.

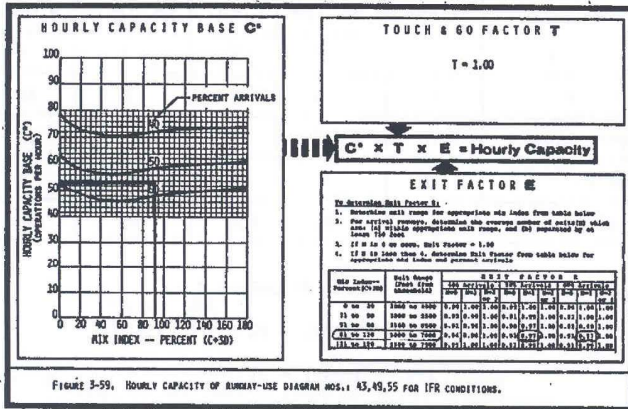
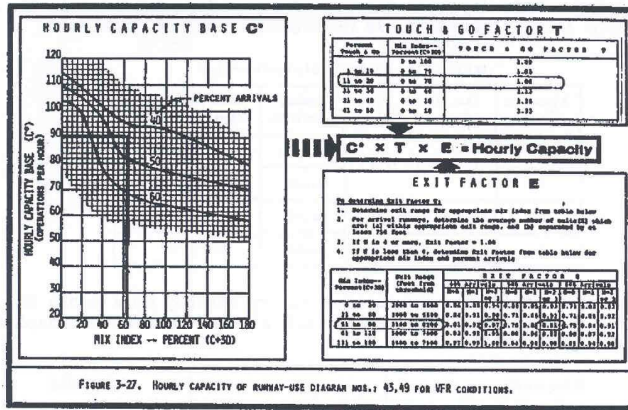
6. Hourly Capacity Base (C*). Obtain C* from figure 3-27 for VFR and 3-59 for IFR, and enter in column 14.

7. Touch and Go Factor (T). The statement specified 3 touch and gos during VFR and none in IFR. Since a touch and go is a landing and a takeoff (2 operations), the percent of touch and go operations in VFR conditions is 6/50 or 12 percent. Obtain the touch and go factor T from figure 3-27 for VFR and 3-59 for IFR and enter in column 15.

Weather	Runway-use Diagram	Capacity Figure No.	Aircraft Mix				Mix Index (C+3D)	Percent Arrivals	Percent Touch & Go	Runway Exit (80 feet)		Hourly Cap. Base C*	T & G Factor	Exit Factor	Hourly Capacity (000) per hr	
			SA	SB	SC	SD				No.	Location					
VFR	↕	3-27	26	20	50	4	62	45	12	45	60	2	89	1.06	.94	89
IFR		3-59	6	15	73	6	91	55	0	60		1	53	1.00	.97	51

Work sheet for runway hourly capacity.

Calcolo capacità oraria Runway (7)



8. **Exit Factor E.** A landing aircraft might exit at the runway intersection (1600 feet) or at one of the three right-angled exits located 3000, 4500, and 6000 feet from the threshold. From figures 3-27 for VFR and 3-59 for IFR, determine the exit range and the exit factor E. In this example, only two exits are within the range between 3500 to 7000 feet. Enter the exit locations in columns 12 and the number of usable exits in column 13. The exit factors E are entered in column 16.

9. **Calculate Capacity.** Compute the hourly capacity of the runway-use configuration and enter in column 17.

$$\text{VFR Capacity} = 89 \cdot 1.06 \cdot 0.94 = 88.68 \text{ or } 89 \text{ operations per hour}$$

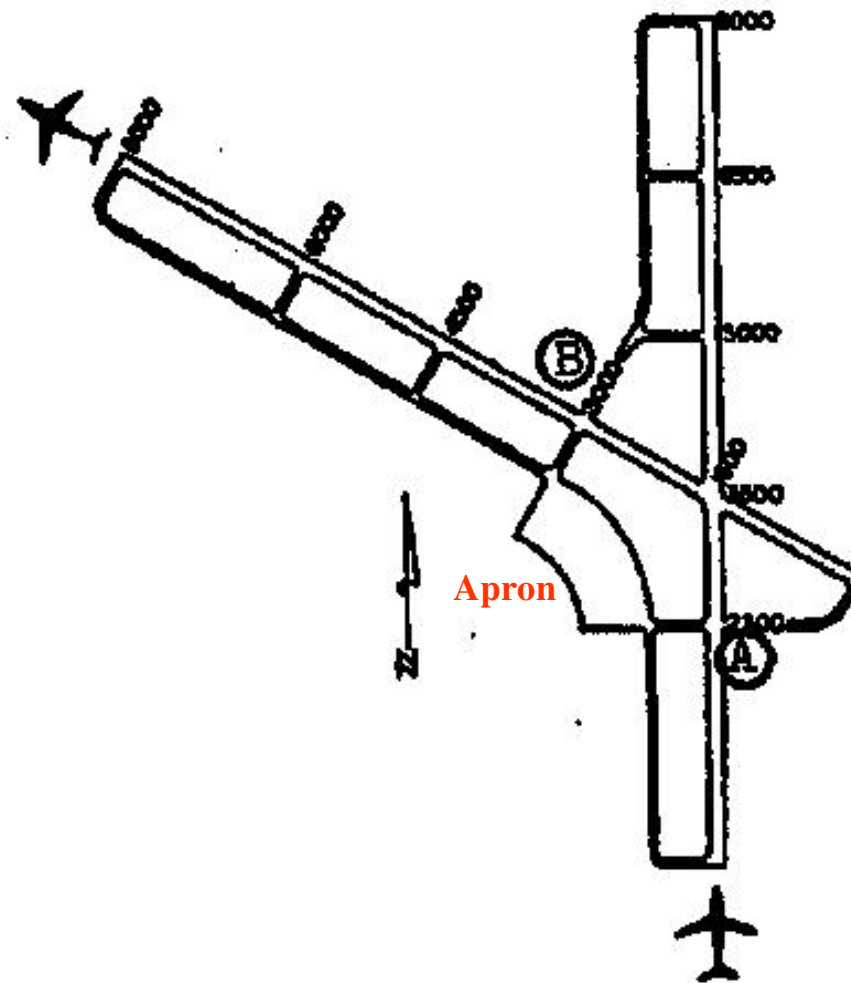
$$\text{IFR Capacity} = 53 \cdot 1.00 \cdot 0.97 = 51.41 \text{ or } 51 \text{ operations per hour}$$

Weather	Runway-use Diagram No.	Capacity Figure No.	Aircraft Mix (C+30)					Percent Arrivals	Percent Touch & Go	Runway Exits (50 feet)			Hourly Capacity Base C*	Exit Factor T	Exit Factor E	Hourly Capacity (500) (C*·T·E)
			GA	MD	TC	TD	TD			No.	No.	No.				
			1	2	3	4	5									
VFR	43	3-27	26	20	50	4	62	45	12	45	60	2	89	1.06	.94	89
IFR		3-59	6	15	73	6	91	55	0	60		1	53	1.00	.97	51

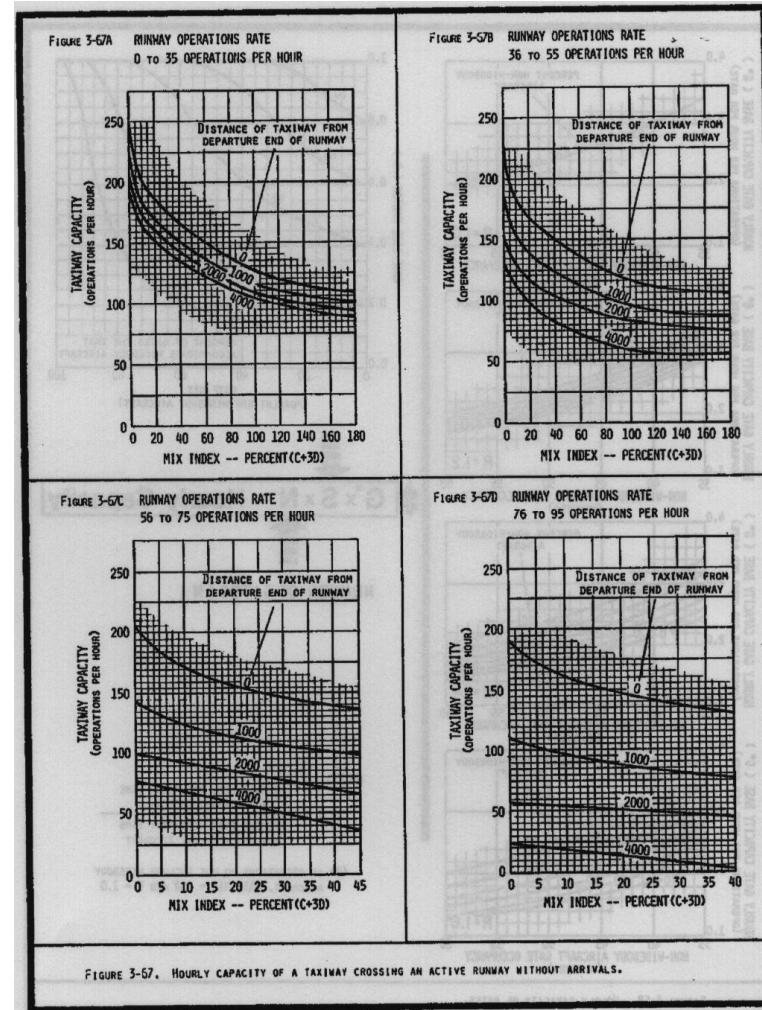
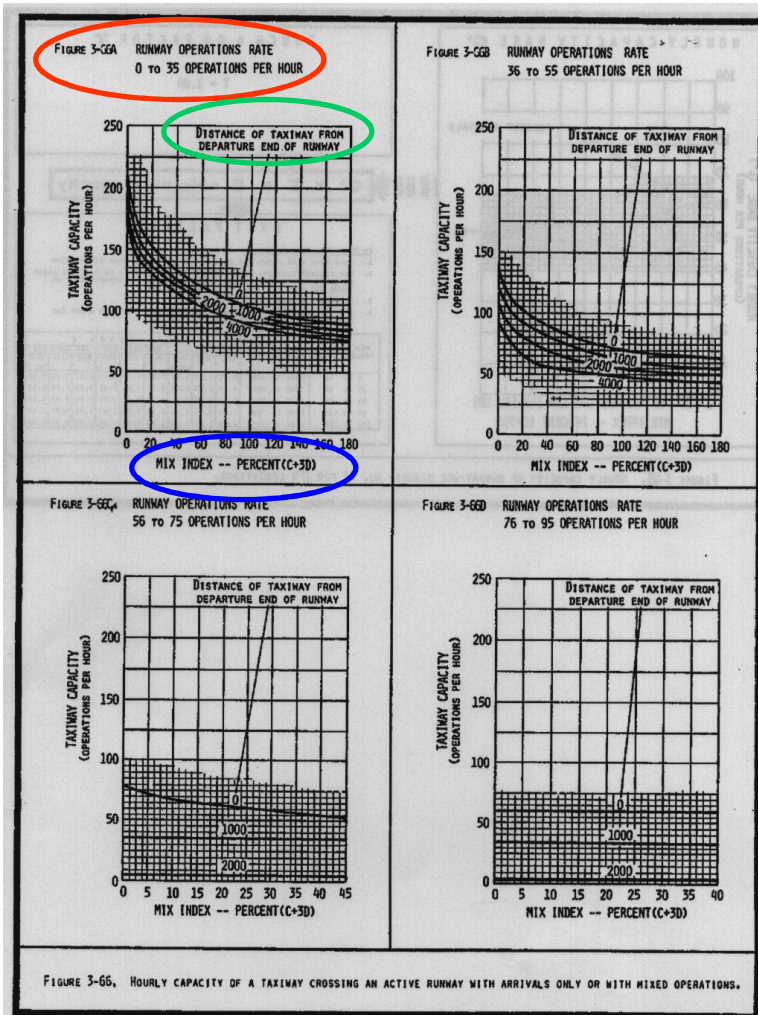
Work sheet for runway hourly capacity.

10. **Conclusion.** The calculated hourly capacities of the runway-use configuration of 89 operations per hour in VFR conditions and 51 operations per hour in IFR conditions exceeds the aeronautical demands of 50 VFR operations and 34 IFR operations specified in the statement.

Calcolo capacità oraria Taxiway (1)



Calcolo capacità oraria Taxiway (2)



Calcolo capacità oraria Taxiway (3)

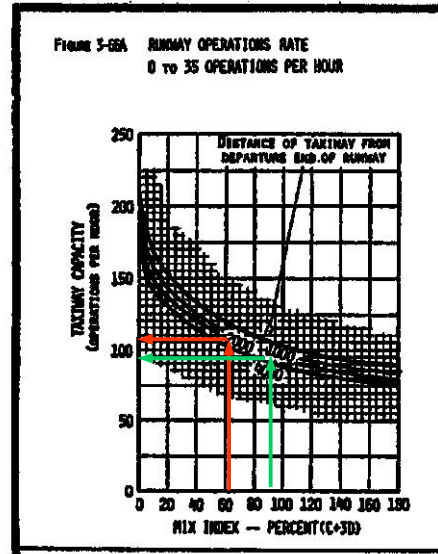
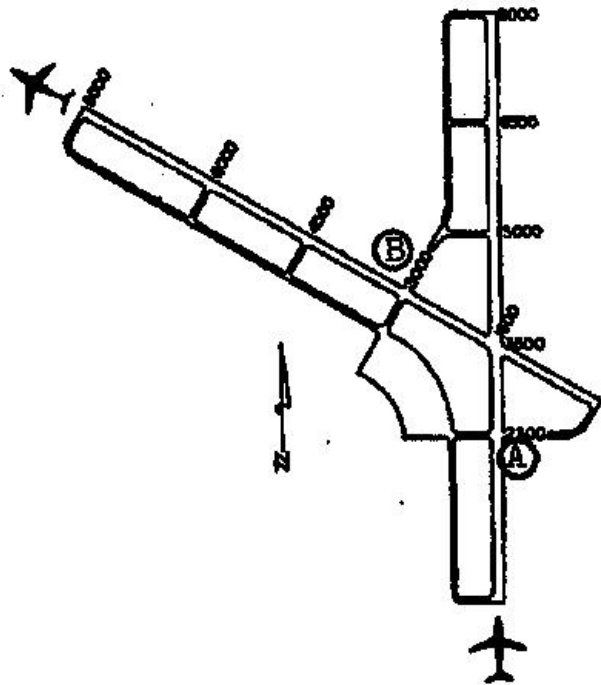


Figure 3-66 (arrivals).

Taxiway A

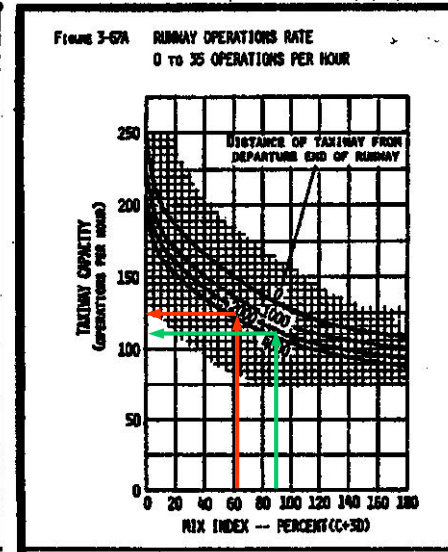


Figure 3-67 (departures).

Taxiway B

Weather	Taxiway Crossing	Distance from Threshold	Runway		Taxiway Crossing Capacities (Operations per Hour)	
			Ops. Rate	Mix Index	Arrivals and Mixed Operations	Departures Plus T & G
1	2	3	4	5	6	7
VFR	A	2300'	24	62	107	-
"	B	3000'	20	62	-	125
IFR	A	2300'	15	91	92	-
"	B	3000'	19	91	-	112

Calcolo capacità oraria Gate (1)

$$u_k \cdot N_k = \left(\sum_i m_i \cdot \frac{T_i}{60} \right) \cdot C_k$$

$$u_k \cdot N_k \cdot 60 = \left(\sum_i m_i \cdot T_i \right) \cdot C_k$$



Tempo disponibile > Tempo richiesto

u_k = fattore di utilizzazione (percentuale di tempo, 0 – 1) del gruppo di gates (indicati k) che possono accogliere gli aerei di tipo i

N_k = numero gates (indicati k) che possono accogliere gli aerei di tipo i

m_i = % di aerei del gruppo i che opera sull'aeroporto

T_i = tempo di servizio del gate per l'aereo di tipo i (minuti)

C_k = Capacità aeroporto nella condizione di utilizzo k (Aerei/ora)

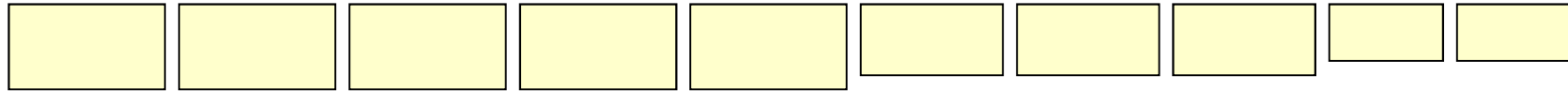
$$u \cdot N = \left(\sum_i m_i \cdot \frac{T_i}{60} \right) \cdot C$$

$$C = \min[C_k]$$

Calcolo capacità oraria Gate (2)

Esempio - Mix traffico: A $m_A = 0,3$ $T_A = 60$; B $m_B = 0,5$ $T_B = 45$; $m_C = 0,2$ $T_C = 30$

10 gate - Operatività $N_1 = 5$ utilizzabili da aerei A ; $N_2 = 8$ da aerei B; $N_3 = 10$ da aerei C



$$u_k \cdot N_k \cdot 60 = \left(\sum_i m_i \cdot T_i \right) \cdot C_k$$

$$1 * 5 * 60 = 0,3 * 60 * C_1$$

$$C_1 = 16,67$$

$$1 * 8 * 60 = [0,3 * 60 + 0,5 * 45] * C_2$$

$$C_2 = 11,85$$

$$1 * 10 * 60 = [0,3 * 60 + 0,5 * 45 + 0,2 * 30] * C_3$$

$$C_3 = 12,90$$

$$1 * 10 * 60 = 600 > [0,3 * 60 + 0,5 * 45 + 0,2 * 30] * 11,85 = 551$$

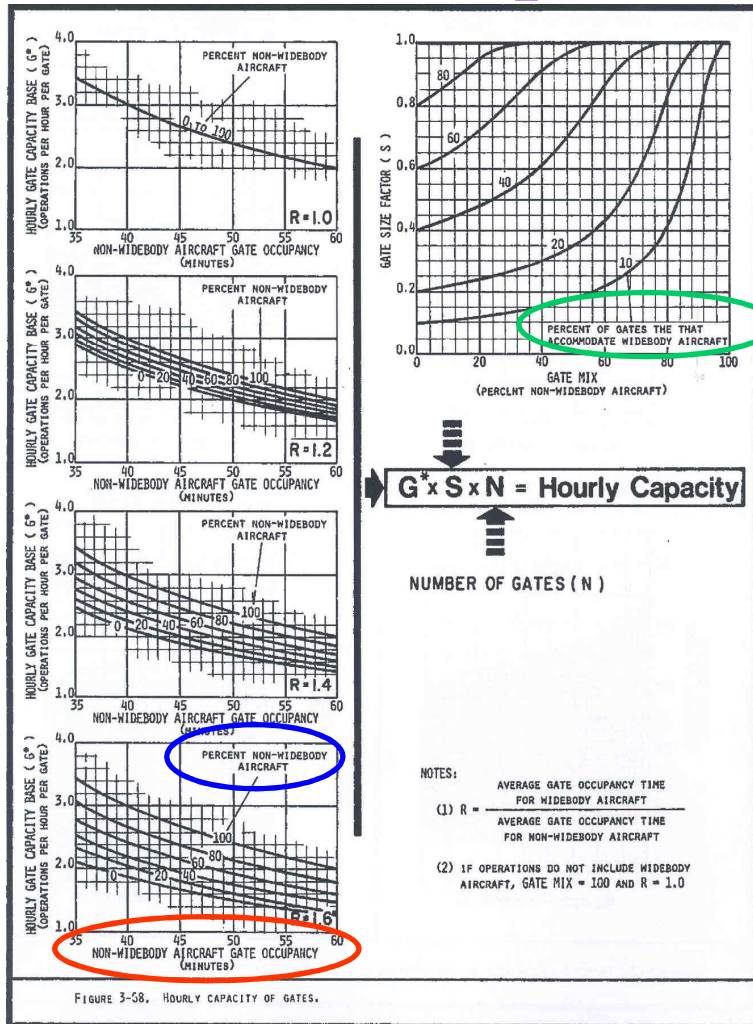
Tempo disponibile > Tempo richiesto

Condizione k=1: $0,3 * 16,67 * 60 / 60 = 5$ ok; $0,5 * 16,67 * 45 / 60 = 6,25 > 3$; $0,2 * 16,67 * 30 / 60 = 1,67$ ok

Condizione k=2: $0,3 * 11,85 * 60 / 60 = 3,55$ ok; $0,5 * 11,85 * 45 / 60 = 4,45$ ok; $0,2 * 11,85 * 30 / 60 = 1,19$ ok

Condizione k=3: $0,3 * 12,90 * 60 / 60 = 3,87$ ok; $0,5 * 12,90 * 45 / 60 = 4,84 > 4,13$; $0,2 * 12,90 * 30 / 60 = 1,29$ ok

Calcolo capacità oraria Gate, FAA (1)



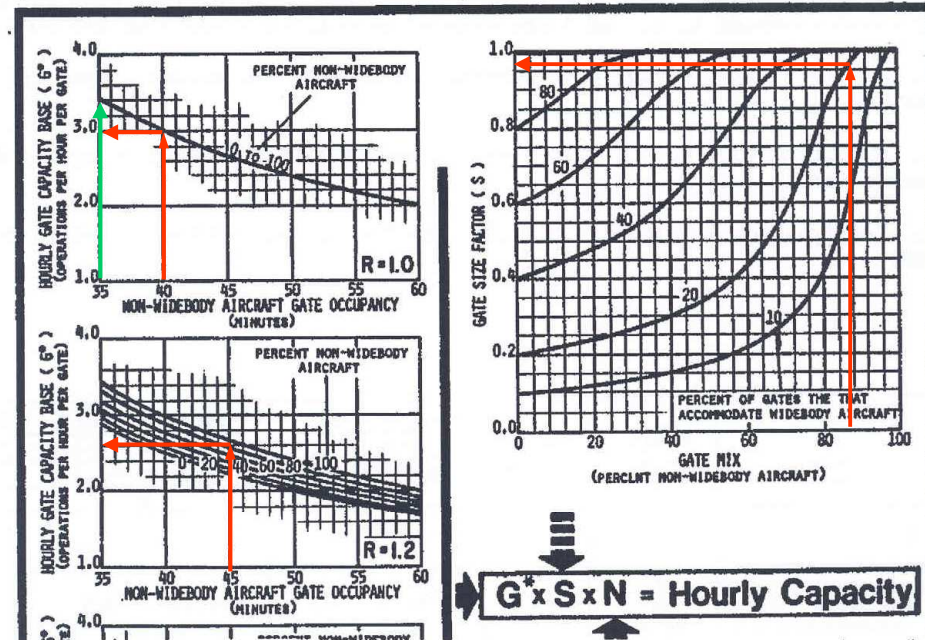
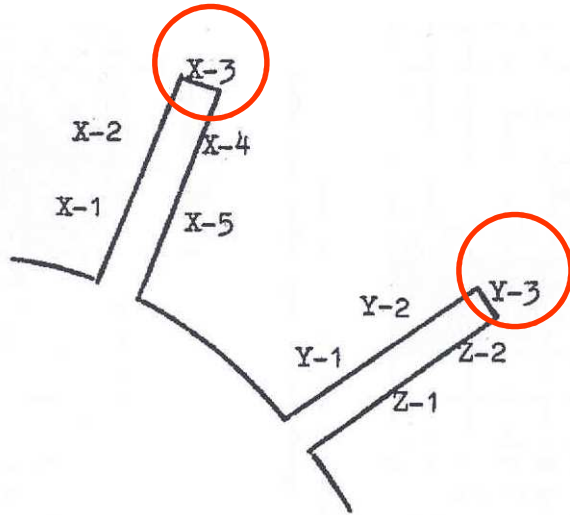
$$HC_i = G^* \cdot S \cdot N$$

HC_i = capacità oraria dei gates di una compagnia

$$HC_T = \sum_{i=1}^n HC_i$$

HC_T = capacità oraria del terminal

Calcolo capacità oraria Gate, FAA (2)



Non-widebody (N) Widebody (W) % Gate per widebody

Gate Group	Demand		No. Gates		Gate Mix		Average Gate Time (Min.)		Gate Occupancy Ratio (T_w/T_n) (R)	Hourly Capac. Base (G^*)	Gate Size (S)	No. Gates (N)	Hourly Capacity ($G^* \cdot S \cdot N$)
	(N)	(W)	(N)	(W)	(N)	(W)	(N)	(W)					
X	13	2	4	1	87	20	45	55	1.22	2.6	.97	5	13
Y	8	0	2	1	100	33	40	0	1.00	3.0	1.00	3	9
Z	4	0	2	0	100	0	35	0	1.00	3.4	1.00	2	7
% aerei NON widebody												Capacity of the Terminal	29

Calcolo capacità oraria Aeroporto

Numero
operazioni
orarie

Component	Hourly Capacity	Hourly Demand	Demand Ratio	Component Quotient
			$\frac{\text{Component Demand}}{\text{Runway Demand}}$	$\frac{\text{Component Capacity}}{\text{Demand Ratio}}$
1	2	3	4	5
Runway	89	50	$50/50 = 1.00$	$89/1.00 = 89$
Twy King A	107	20	$20/50 = .40$	$107/.40 = 267$
Twy King B	125	24	$24/50 = .48$	$125/.48 = 260$
Gates	29	27	$27/50 = .54$	$29/.54 = 54$

$$107/0,48 = 222$$

$$125/0,40 = 312$$

Volume annuale di servizio (1)

Operating Condition			Mix Index	Percent of Year (P)	Hourly Capacity (C)	Percent Maximum Capacity	Weighting Factor (W)
No.	Weather	Run-use Diagram					
1	2	3	4	5	6	7	8
1	VFR		62	74	89	100	1
2	IFR		91	5	51	57	20
3	VFR		62	5	62	70	15
4	IFR		91	5	52	58	20
5	VFR		62	4	59	66	15
6	IFR		91	4	46	52	20
7	IFR	Below Minimums		3		-	25

Percent of Maximum Capacity	Weighting Factors			
	VFR	IFR		
		Mix Index (0-20)	Mix Index (21-50)	Mix Index (51-180)
91+	1	1	1	1
81-90	5	1	3	5
66-80	15	2	8	15
51-65	20	3	12	20
0-50	25	4	16	25

Capacità oraria pesata

$$C_w = \frac{(P_1 \cdot C_1 \cdot W_1) + (P_2 \cdot C_2 \cdot W_2) + \dots + (P_n \cdot C_n \cdot W_n)}{(P_1 \cdot W_1) + (P_2 \cdot W_2) + \dots + (P_n \cdot W_n)} = \frac{287,56}{5,64} \cong 51 \text{ op./ora}$$

$$C_w = \frac{(0,74 \cdot 89 \cdot 1) + (0,05 \cdot 51 \cdot 20) + \dots + (0,03 \cdot 0 \cdot 25)}{(0,74 \cdot 1) + (0,05 \cdot 20) + \dots + (0,03 \cdot 25)} = \frac{287,56}{5,64} \cong 51 \text{ op./ora}$$

Volume annuale di servizio (2)

$$C_w = \frac{(P_1 \cdot C_1 \cdot W_1) + (P_2 \cdot C_2 \cdot W_2) + \dots + (P_n \cdot C_n \cdot W_n)}{(P_1 \cdot W_1) + (P_2 \cdot W_2) + \dots + (P_n \cdot W_n)} = \frac{287,56}{5,64} \cong 51 \text{ op./ora}$$

$$D = \frac{NO}{AD, PM} = \frac{219.750}{690} = 318$$

$$H = \frac{AD, PM}{APH, PM} = \frac{690}{50} = 14$$

$$ASV = C_w * D * H = (\text{Op/ora}) * (\text{Op/anno})/(\text{Op/giorno}) * (\text{Op/giorno})/(\text{Op/ora})$$

$$ASV = 51 * 318 * 14 = 227.052 \text{ Op./anno}$$

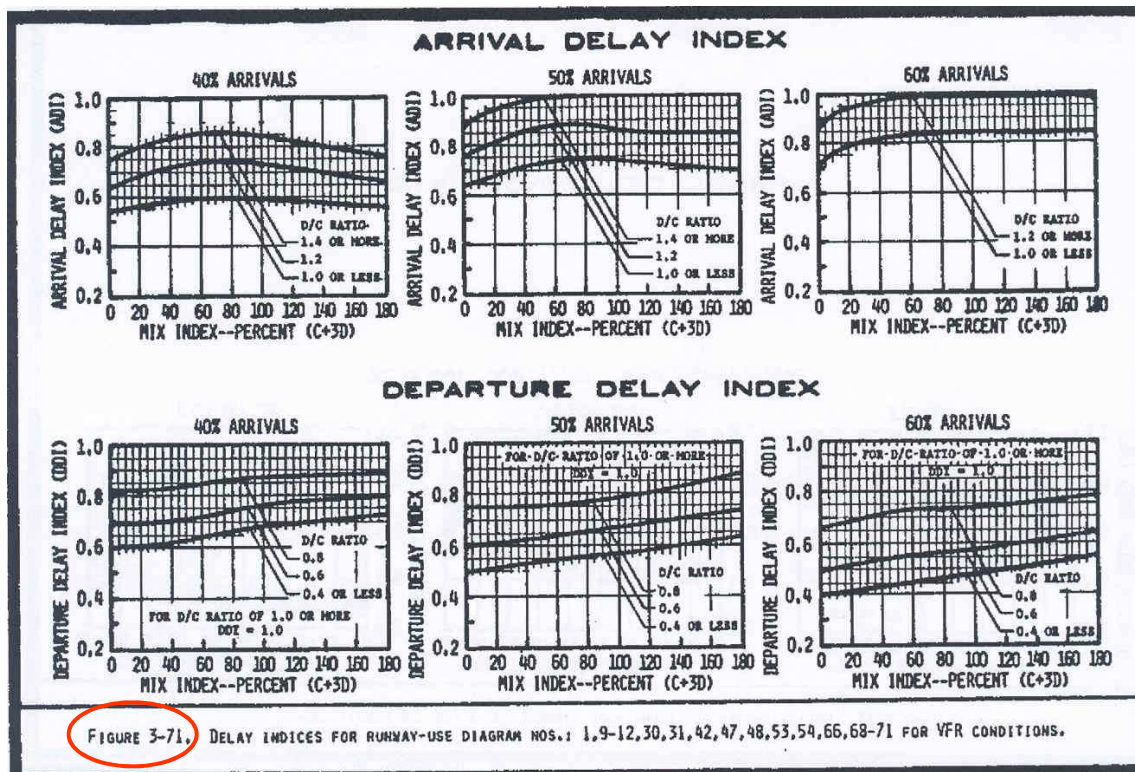
Mix Index	Daily (D)	Hourly (H)
0-20	280-310	7-11
21-50	300-320	10-13
51-180	310-350	11-15

Ritardo orario sulle Runway (1)

DIAGRAM	DIAG. No.	RUNWAY SPACING 50 FEET (S)	FIGURE NO.			
			FOR CAPACITY		FOR DELAY	
			VFR	IFR	VFR	IFR
	1	NA	3-3	3-43	3-71	3-90
	2	700 OR MORE	3-4	3-44	3-72	3-91
	3	700 TO 2499	3-5	3-44	3-73	3-91
	4	2500 OR MORE	3-6	3-45	3-74	3-92
	5*	700 TO 2499	3-7	3-44	3-75	3-91
	6	2500 TO 2999	3-8	3-45	3-75	3-93

ADF = ADI (D/C)

DDF = DDI (D/C)



Ritardo orario sulle Runway (2)

$$DPF = 100 * Q / HD$$

HD domanda oraria

Q domanda di picco nei 15 min.

DPF fattore di profilo della domanda

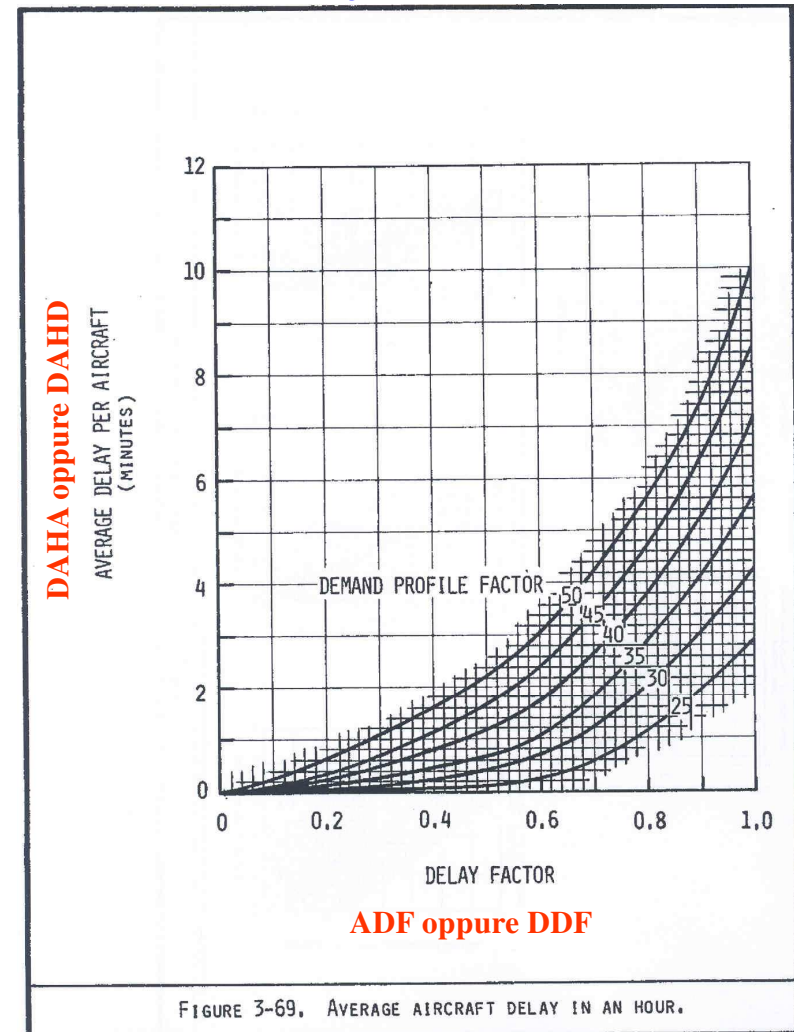
$$DTH = HD * (PA * DAHA + (100-PA) * DAHD)/100$$

DTH ritardo orario totale

PA % arrivi

DAHA ritardo orario medio arrivi

DAHD ritardo orario medio partenze



Ritardo orario sulle Runway (3)

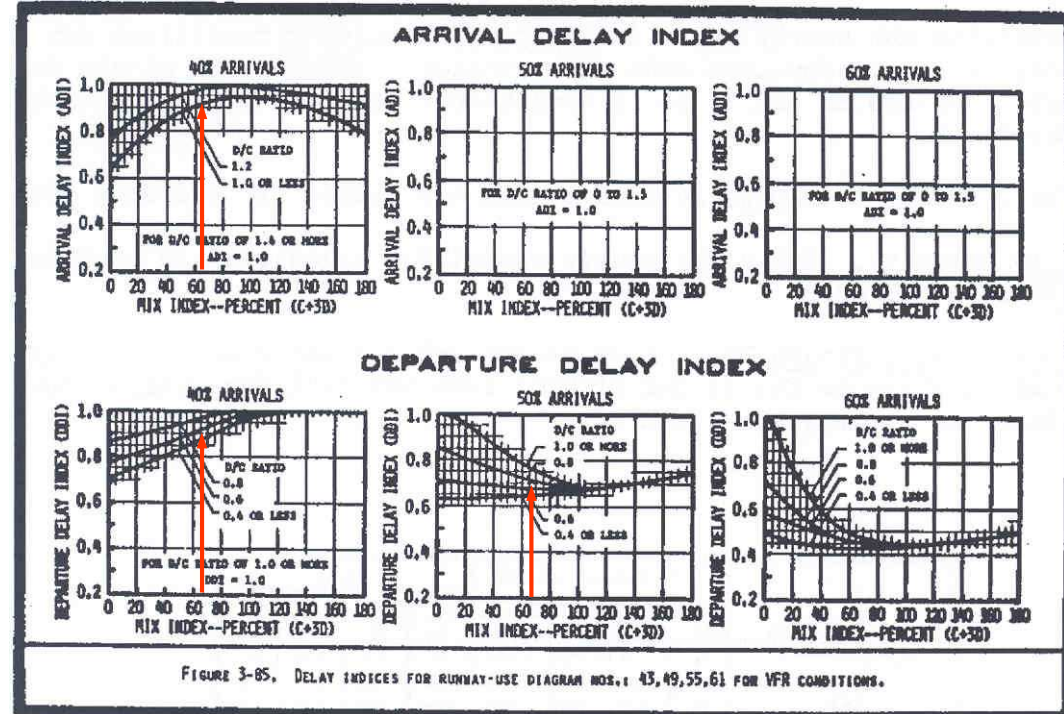
RUNWAY-USE DIAGRAM	DIAG. No.	RUNWAY INTERSECTION DISTANCE IN FEET		FIGURE NO.			
		(x)	(y)	FOR CAPACITY		FOR DELAY	
				VFR	IFR	VFR	IFR
	43	0 to 1999	< 4000	3-27	3-59	3-85	3-91
	44	2000 to 4999	< 4000	3-28	3-60	3-86	3-99
	45	5000 to 8000	< 4000	3-29	3-61	3-86	3-99
	46	0 to 1999	> 4000	3-30	3-62	3-86	3-99
	47	2000 to 4999	> 4000	3-31	3-63	3-71	3-102
	48	5000 to 8000	> 4000	3-32	3-64	3-71	3-102
	49	0 to 1999	< 4000	3-27	3-59	3-85	3-91
	50	2000 to 4999	< 4000	3-28	3-60	3-86	3-99
	51	5000 to 8000	< 4000	3-29	3-61	3-86	3-99
	52	0 to 1999	> 4000	3-30	3-62	3-86	3-99
	53	2000 to 4999	> 4000	3-31	3-63	3-71	3-90
	54	5000 to 8000	> 4000	3-32	3-64	3-71	3-90

% 40 ADI = 0,90 DDI = 0,90

% 50 ADI = 1,00 DDI = 0,67

% 45 ADI = 0,95 DDI = 0,78

dati



Run-use Configuration Diagram	Delay Fig. No.	VFR	IFR	Capacity	Demand		D/C Ratio	Percent Arrivals	Mix Index	Arrival Delay Index		Depart. Delay Index		Demand Profile Factor DPF	Avar. Delay (Minutes)		Hourly Delay (Minutes)
					Hourly	15 Min.				ADI	ADF	DDI	DDF		Acc.	Dep.	
	43	85		89	50	20	.56	45	62	.95	.53	.78	.44	40	1.3	.95	55
	43	91		51	34	15	.67	55	91	1.00	.67	.47	.31	44	2.9	.60	53

ADF = ADI (D/C)

DDF = DDI (D/C)

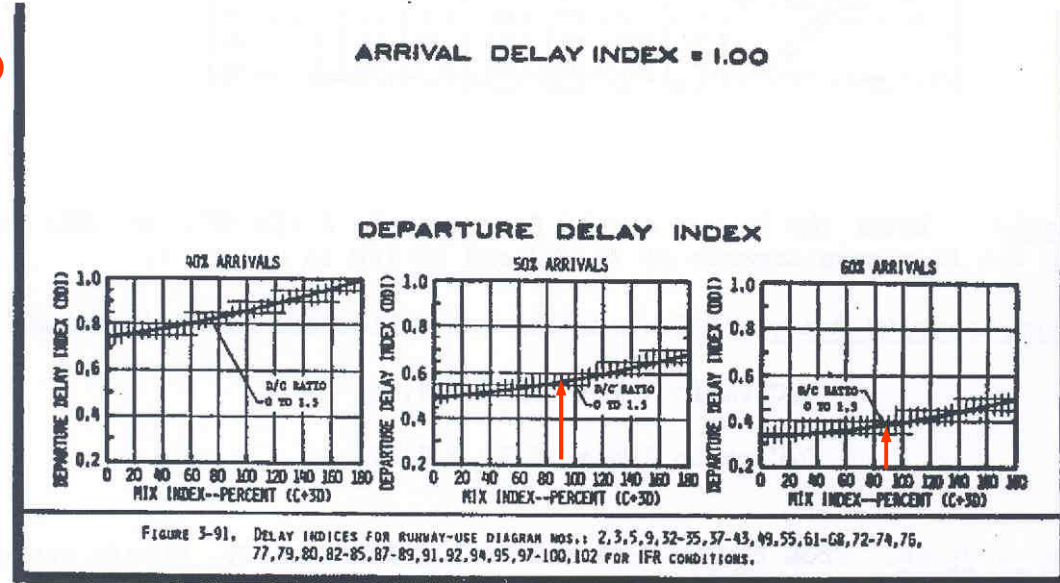
Ritardo orario sulle Runway (4)

RUNWAY-USE DIAGRAM	DIAG. No.	RUNWAY INTERSECTION DISTANCE IN FEET		FIGURE NO.			
		(x)	(y)	FOR CAPACITY		FOR DELAY	
				VFR	IFR	VFR	IFR
	43	0 to 1999	4000	3-27	3-59	3-85	3-91
	44	2000 to 4999	4000	3-28	3-60	3-86	3-99
	45	5000 to 8000	4000	3-29	3-61	3-86	3-99
	46	0 to 1999	4000	3-30	3-62	3-86	3-99
	47	2000 to 4999	4000	3-31	3-63	3-71	3-102
	48	5000 to 8000	4000	3-32	3-64	3-71	3-102
	49	0 to 1999	4000	3-27	3-59	3-85	3-91
	50	2000 to 4999	4000	3-28	3-60	3-86	3-99
	51	5000 to 8000	4000	3-29	3-61	3-86	3-99
	52	0 to 1999	4000	3-30	3-62	3-86	3-99
	53	2000 to 4999	4000	3-31	3-63	3-71	3-90
	54	5000 to 8000	4000	3-3	3-43	3-71	3-90

% 40 ADI = 1,00 DDI = 0,57

% 50 ADI = 1,00 DDI = 0,38

% 45 ADI = 1,00 DDI = 0,47



Runway Configuration Sketch	Delay Fig. No.	Capacity	Demand		D/C Ratio	Percent Arrivals	Mix Index	Arrival Delay Index		Depart. Delay Index		Demand Profile Factor DPF	Avar. Delay (Minutes)		Hourly Delay (Minutes)
			Hourly	15 Min.				ADI	ADF	DDI	DDF		Acc.	Dep.	
	43	89	50	20	.56	45	62	.95	.53	.78	.44	40	1.3	.95	55
	43	91	51	34	.67	55	91	1.00	.67	.47	.31	44	2.9	.60	53

ADF = ADI (D/C)

DDF = DDI (D/C)

Ritardo orario sulle Runway (5)

Runway Configuration Sketch	Delay Fig. No.		Capacity	Demand		D/C Ratio	Percent Arrivals	Mix Index	Arrival Delay Index		Depart. Delay Index		Demand Profile Factor DPF	Aver. Delay (Minutes)		Hourly Delay (Minutes)
	No.	VFR IFR		Hourly	15 Min.				ADI	ADF	DDI	DDF		Arr.	Dep.	
↕	43	85	89	50	20	.56	45	62	.95	.53	.78	.44	40	1.3	.95	55
	43	91	51	34	15	.67	55	91	1.00	.67	.47	.31	44	2.9	.60	53

$$DPF = 100 * Q / HD$$

DPF fattore del profilo di domanda

HD domanda oraria

Q domanda di picco nei 15 min.

$$DTH = HD * (PA * DAHA + (100-PA) * DAHD)/100$$

Per VFR $DTH = 50 * (45 * 1,3 + (100-45) * 0,95)/100 = 55 \text{ min}$

Per IFR $DTH = 34 * (55 * 2,9 + (100-55) * 0,60)/100 = 53 \text{ min}$

DAHA oppure DAHD
AVERAGE DELAY PER AIRCRAFT
(MINUTES)

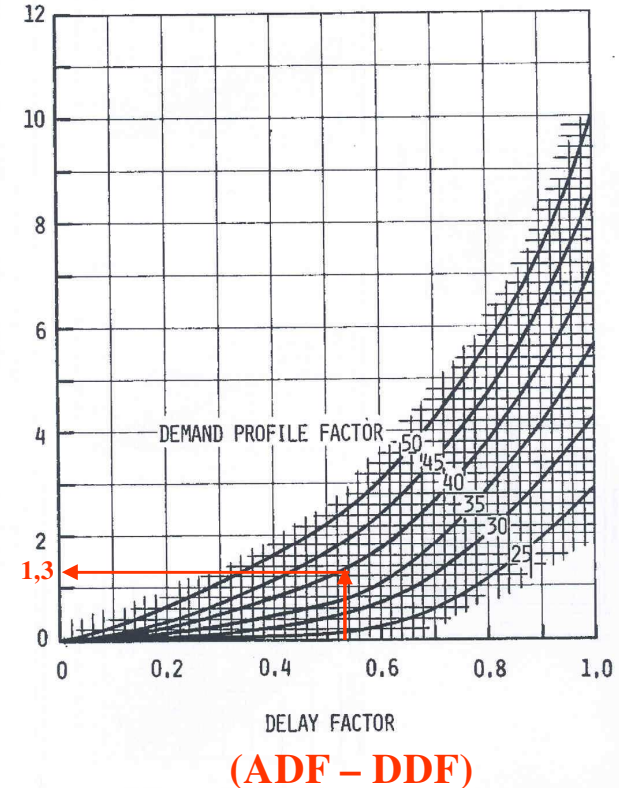
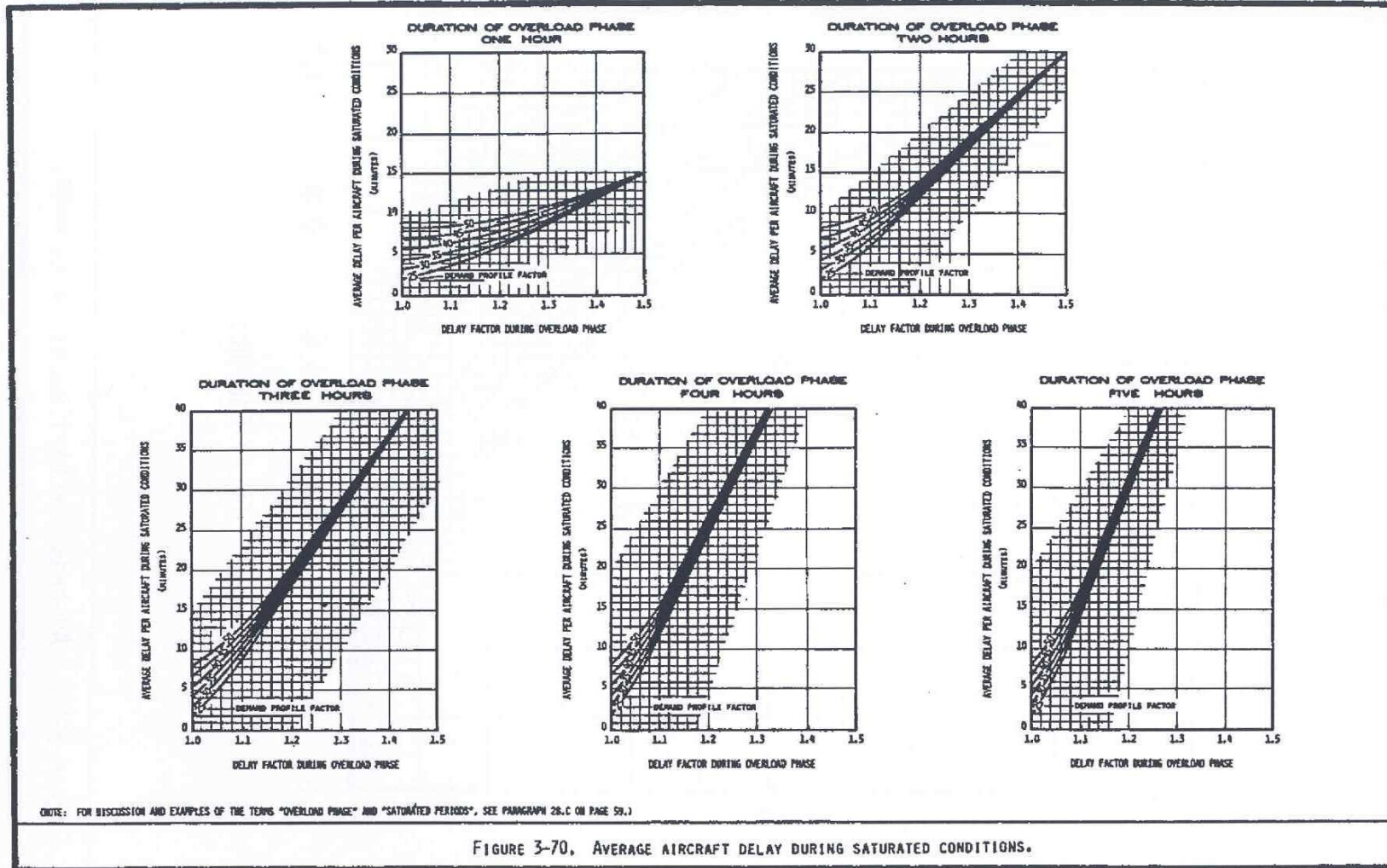
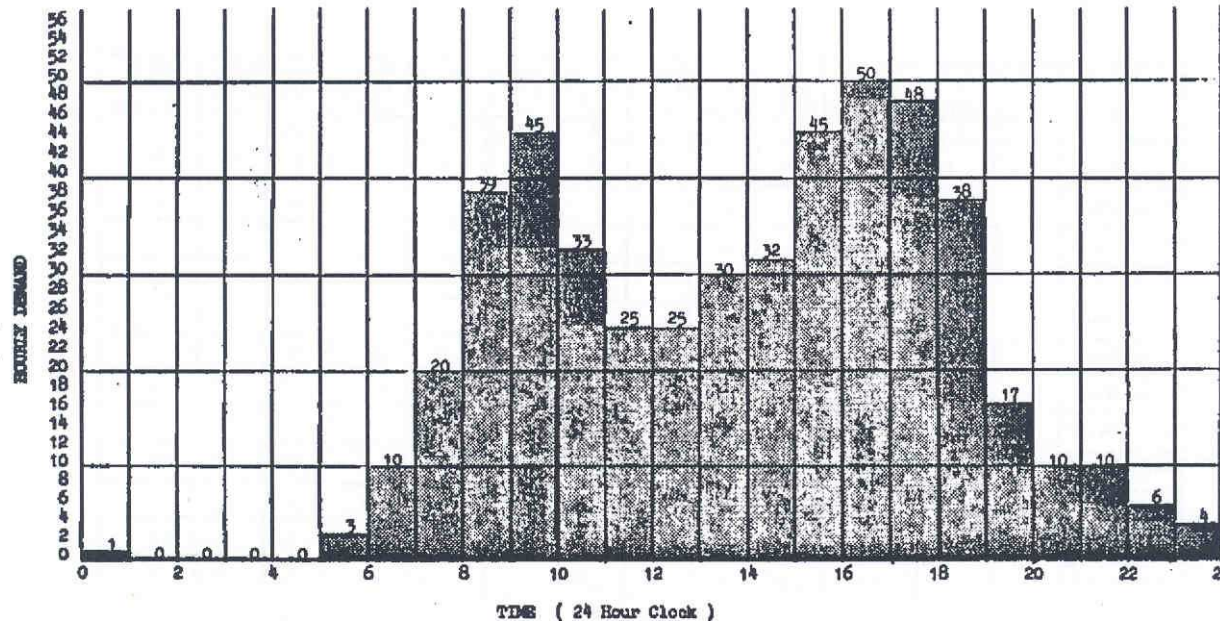


FIGURE 3-69. AVERAGE AIRCRAFT DELAY IN AN HOUR.

Ritardo giornaliero sulle Runway (1)



Ritardo giornaliero sulle Runway (2)



% aerei

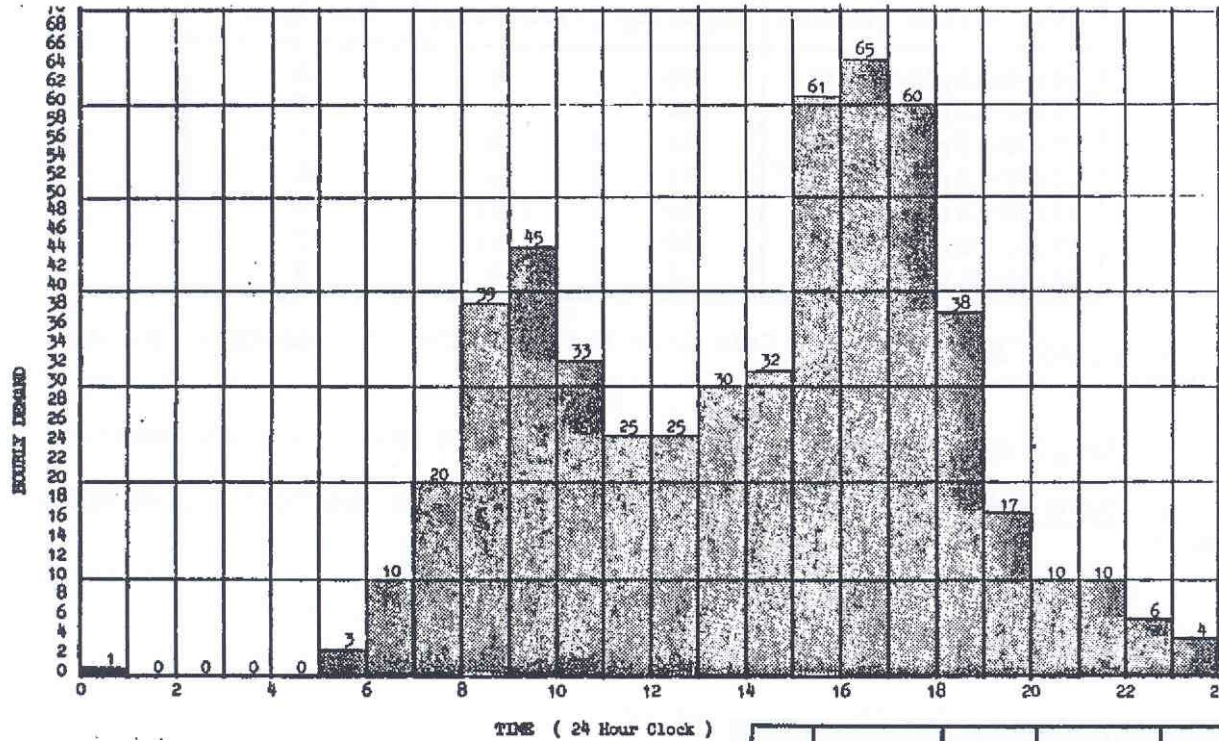
Demand	Runway-use Diagram	Capacity Figure No.		Aircraft Mix				Mix Index a(C+3D)	Arrivals	Touch and Go	Runway Exits			Hourly Cap. Base C*	F a G Factor Y	Exit Factor E	Hourly Capacity (000) C*·Y·E	
		1	2	1A	1B	2C	3D				13	14	15					
11-19		1	3	23	75	2	0	2	50	5	30	45	60	1	103	1.04	.86	92
11-19		43	27	40	55	5	0	5	"	20	"	"	"	1	108	1.08	.85	97
20-35		"	"	35	35	30	0	30	"	10	"	"	"	2	102	1.03	.92	97
36-44		"	"	30	27	42	1	45	50	8	"	"	"	"	94	1.03	.92	89
45+		43	27	26	20	50	4	62	45	12	30	45	60	2	88	1.06	.94	89

Ritardo giornaliero sulle Runway (3)

Hour	Misc.	Hourly		D/C Ratio	Mix Index	Arrival Delay		Depart. Delay		Delay Factor DFF	Aves. Delay (Minutes)		Hourly Delay (Minutes)
		Demand	Capacity			Index ADI	Factor ADP	Index DDI	Factor DDP		Arr.	Dep.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
24:00-01:00		1	92	.01	0	0	0	0	0	0	0	0	0
01:00-02:00		0	-	-	-	-	-	-	-	-	-	-	-
02:00-03:00		"	-	-	-	-	-	-	-	-	-	-	-
03:00-04:00		"	-	-	-	-	-	-	-	-	-	-	-
04:00-05:00		"	-	-	-	-	-	-	-	-	-	-	-
05:00-06:00		3	92	.03	0	.64	.02	.50	.01	25	0	0	0
06:00-07:00		10	92	.11	2	.64	.07	.50	.06	40	.05	.05	1
07:00-08:00		20	97	.21	30	1.00	.21	.63	.13	"	.30	.15	4
08:00-09:00		39	89	.44	45	1.00	.44	.65	.29	"	.95	.50	28
09:00-10:00		45	"	.51	62	.95	.48	.78	.37	"	1.10	.80	42
10:00-11:00		33	89	.37	30	1.00	.37	.63	.23	"	.70	.35	17
11:00-12:00		25	97	.26	"	"	.26	"	.16	"	.40	.20	7
12:00-13:00		25	97	.26	"	"	.26	"	.16	"	.40	.20	7
13:00-14:00		30	89	.34	"	"	.34	"	.21	"	.60	.30	14
14:00-15:00		32	"	.36	30	1.00	.36	.63	.23	"	.65	.35	16
15:00-16:00		45	"	.51	62	.95	.48	.78	.39	"	1.10	.80	42
16:00-17:00		50	"	.56	"	"	.53	"	.44	"	1.30	.95	55
17:00-18:00		48	"	.54	62	.95	.51	.78	.43	"	1.20	.90	50
18:00-19:00		38	89	.43	45	1.00	.43	.65	.28	"	.90	.40	25
19:00-20:00		17	97	.18	5	"	.18	.63	.11	"	.25	.15	4
20:00-21:00		10	"	.10	"	"	.10	"	.06	"	.05	.05	1
21:00-22:00		10	97	.10	5	1.00	.10	.63	.06	40	.05	.05	1
22:00-23:00		6	92	.07	2	.64	.04	.50	.04	25	0	0	0
23:00-24:00		4	92	.04	0	.64	.03	.50	.02	25	0	0	0
												Daily Delay	295

Dati

Ritardo giornaliero sulle Runway (4)



Period	Runway-use		Capacity		Aircraft Mix				Mix Index I(C+3D)	Arrivals A	Touch and Go T	Runway Mix			Rly. Cap. Base C ^o	T & G Factor T	Exit Factor E	Hourly Capacity (000) C ^o ·T·E
	No.	Fig.	VRN	IPN	SA	SB	SC	SD				Location	No.	13				
11-19	1	3	40	55	5	0	5	50	20	30	45	60	1	97	1.10	.86	92	
20-35	"	"	35	35	30	0	30	50	10	"	"	"	2	71	1.04	.93	69	
36-44	"	"	30	27	42	1	45	45	8	"	"	"	"	65	1.04	.93	63	
45-50	"	"	26	20	50	4	62	"	12	"	"	"	"	62	1.10	.91	62	
51-59	"	"	21	17	59	3	68	"	10	"	"	"	"	61	1.04	.91	58	
60+	1	3	20	15	62	3	71	45	9	30	45	60	2	58	1.04	.91	55	

Ritardo giornaliero sulle Runway (5)

Time Period	Demand	Capacity	Overload (Recovery)	Cummulative Overload
14:00-15:00	32	69	0	0
15:00-16:00	61	55	6	6
16:00-17:00	65	55	10	16
17:00-18:00	60	55	5	21
18:00-19:00	38	55	(17)	4
19:00-20:00	17	55	(4)	0
20:00-21:00	10	92	0	0

$$AD/C = (61+65+60)/(55+55+55) = 1,13$$



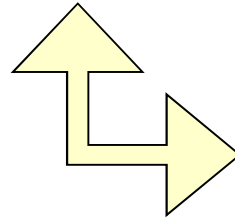
Hour	Mec.	Hourly		D/C Ratio	Mix Index	Arrival Delay		Depart. Delay		Delay Factor DFF	Aver. Delay (Minutes)		Hourly Delay (Minutes)
		Demand	Capacity			Index ADI	Factor ANP	Index DOI	Factor DDP		Arr.	Dep.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
13:00-14:00		30	"	.43	"	"	.30	.53	.23	"	0.5	0.3	12
14:00-15:00		32	69	.46	30	.70	.32	.56	.26	40	0.6	0.4	16
15:00-16:00		61	55	1.13	71	.78	.88	1.00	1.13	40	4.9	13.7	2347
16:00-17:00		65	"										
17:00-18:00		60	"										
18:00-19:00		38	"										
19:00-20:00		17	55										
20:00-21:00		10	92	.11	5	.65	.07	.50	.06	40	0.1	0.0	1

Ritardo giornaliero sulle Runway (6)

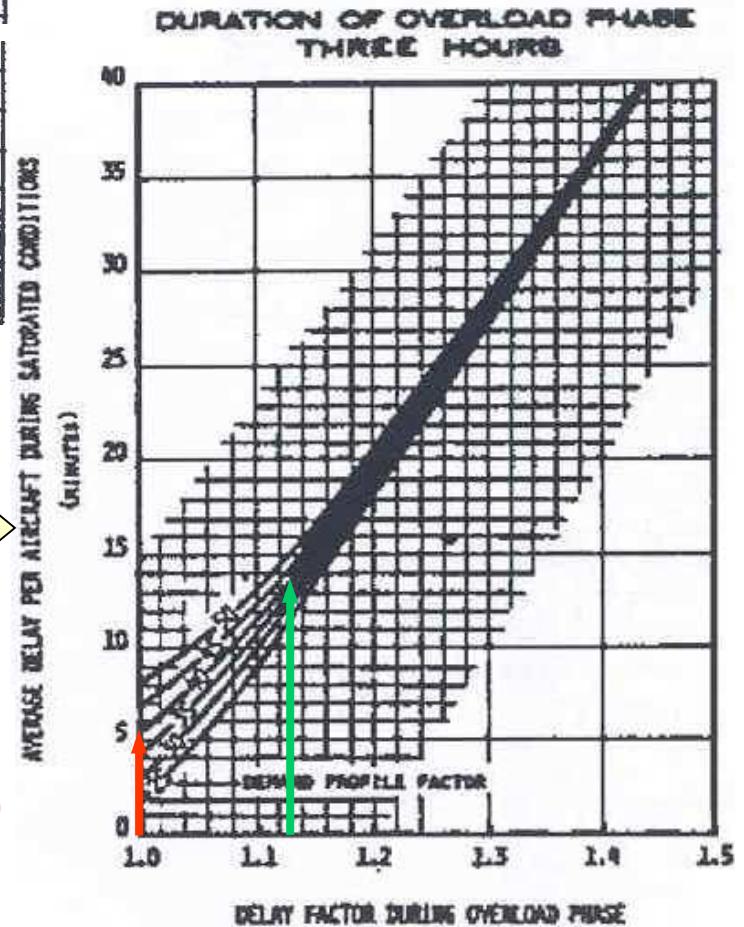
Hour	Mile.	Hourly		D/C Ratio	Mix Index	Arrival Delay		Depart. Delay		Delay Factor DDF	Aver. Delay (Minutes)		Hourly Delay (Minutes)
		Demand	Capacity			Index ADI	Factor ADF	Index DDI	Factor DDF		Arr.	Dep.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
13:00-14:00		30	"	.43	"	"	.30	.53	.23	"	0.5	0.3	12
14:00-15:00		32	69	.46	30	.70	.32	.56	.26	40	0.6	0.4	16
15:00-16:00		61	55	1.13	71	.78	.88	1.00	1.13	40	4.9	13.7	2347
16:00-17:00		65	"										
17:00-18:00		60	"										
18:00-19:00		38	"										
19:00-20:00		17	55										
20:00-21:00		10	92	.11	5	.65	.07	.50	.06	40	0.1	0.0	1

$$ADF = (D/C) * ADI$$

$$DDF = (D/C) * DDI$$



$$\begin{aligned}
 DTS &= [\Sigma(HD)] * [PA * DAHA + (100-PA) * DAHD] / 100 \\
 &= (61+65+60+38+17) * [45 * 4,9 + (100-45) * 13,7] / 100 \\
 &= 2347 \text{ min}
 \end{aligned}$$



Ritardo giornaliero sulle Runway (7)

Hour 1	Mec. 2	Hourly		D/C Ratio 5	Mix Index 6	Arrival Delay		Depart. Delay		Delay Factor DPF 11	Aver. Delay (Minutes)		Hourly Delay (Minutes) 14
		Demand 3	Capacity 4			Index ADI 7	Factor ADP 8	Index DDI 9	Factor DDP 10		Arr. 12	Dep. 13	
24:00-01:00		1	92	-	-	-	-	-	-	-	-	-	-
01:00-02:00		0	"	-	-	-	-	-	-	-	-	-	-
02:00-03:00		0	"	-	-	-	-	-	-	-	-	-	-
03:00-04:00		0	"	-	-	-	-	-	-	-	-	-	-
04:00-05:00		0	"	-	-	-	-	-	-	-	-	-	-
05:00-06:00		3	"	.03	5	.65	.02	.50	.02	40	0.0	0.0	0
06:00-07:00		10	92	.11	5	.65	.07	.50	.06	"	0.1	0.0	1
07:00-08:00		20	69	.29	30	.70	.20	.52	.15	"	0.2	0.2	4
08:00-09:00		39	63	.62	45	.72	.45	.64	.40	"	1.0	0.8	35
09:00-10:00		45	62	.73	62	.67	.49	.74	.54	"	1.1	1.4	57
10:00-11:00		33	69	.48	30	.70	.34	.56	.27	"	0.6	0.4	17
11:00-12:00		25	"	.36	"	"	.25	.52	.19	"	0.4	0.2	8
12:00-13:00		25	"	.36	"	"	.25	.52	.19	"	0.4	0.2	8
13:00-14:00		30	"	.43	"	"	.30	.53	.23	"	0.5	0.3	12
14:00-15:00		32	69	.46	30	.70	.32	.56	.26	40	0.6	0.4	16
15:00-16:00		61	55										
16:00-17:00		65	"	1.13	71	.78	.88	1.00	1.13	40	4.9	13.7	2347
17:00-18:00		60	"										
18:00-19:00		38	"										
19:00-20:00		17	55										
20:00-21:00		10	92	.11	5	.65	.07	.50	.06	40	0.1	0.0	1
21:00-22:00		10	"	.11	"	"	.07	"	.06	"	0.1	0.0	1
22:00-23:00		6	"	.07	"	"	.05	"	.04	"	0.0	0.0	0
23:00-24:00		4	92	.04	5	.65	.03	.50	.02	40	0.0	0.0	0
Daily Delay													2507

Ritardo annuale sulle Runway (1)

Month	No. Days	Demand per Month	Ave. Daily Demand	Weather	Percent Occur.	Representative Day(s)			Monthly Delay (minutes)	
						No. of Days	Demand	Delay	VFR/IFR	Total
1	2	3	4	5	6	7	8	9	10	11
Jan.	31	11,631	375	VFR IFR	82 18	25.4 5.6	398 271	163 116	4,140 650	4,790
Feb	28	10,926	390	VFR IFR	80 20	22.4 5.6	414 282	185 130	4,144 728	4,872
Mar.	31	12,561	405	VFR IFR	85 15	26.4 4.6	430 292	199 146	5,254 146	5,926
Apr.	30	12,096	403	VFR IFR	87 13	26.1 3.9	428 291	193 145	5,037 566	5,603
May	31	12,756	411	VFR IFR	90 10	27.9 3.1	436 296	201 148	5,608 459	6,067
June	30	13,508	450	VFR IFR	92 8	27.6 2.4	478 325	278 195	7,673 468	8,141
July	31	13,832	446	VFR IFR	95 5	29.4 1.6	473 322	270 190	7,938 304	8,242
Aug.	31	15,227	491	VFR IFR	98 2	30.4 0.6	521 354	355 251	10,792 151	10,943
Sep.	30	12,456	415	VFR IFR	98 2	29.4 0.6	440 299	209 150	6,145 90	6,235
Oct.	31	13,119	423	VFR IFR	96 4	29.8 1.2	499 305	225 162	6,705 194	6,899
Nov.	30	12,456	415	VFR IFR	90 10	27.0 3.0	440 299	209 150	5,643 450	6,093
Dec.	31	12,432	401	VFR IFR	85 15	26.3 4.7	426 290	192 143	5,050 672	5,722
Σ(colonna 3) = 153000							TOTALS:	VFR IFR	74,129 5,404	79,533

Ritardo annuale sulle Runway (1)

Month	No. Days	Demand per Month	Ave. Daily Demand	Weather	Percent Occur.	Representative Day(s)			Monthly Delay (minutes)	
						No. of Days	Demand	Delay	VFR/IFR	Total
1	2	3	4	5	6	7	8	9	10	11
Jan.	31	11,631	375	VFR	62	25.4	398	163	4,140	4,790
				IFR	18	5.6	271	116	650	
Feb.	28	10,926	390	VFR	80	22.4	414	185	4,144	4,872
				IFR	20	5.6	282	130	728	

$$DMG = \%G(VFR)*D(VFR)+\%G(IFR)*D(IFR) = [1-\%G(IFR)]*D(VFR)+\%G(IFR)*\%D(IFR/VFR)*D(VFR) =$$

$$= D(VFR)*[1-\%G(IFR)+\%G(IFR)*\%D(IFR/VFR)] = D(VFR)*[1-\%G(IFR)*(1-\%D(IFR/VFR))]$$

$$D(VFR) = DMG/[1-\%G(IFR)*(1-\%D(IFR/VFR))]$$

$$375 = (25,4/31)*D(VFR)+(5,6/31)*D(IFR) = (25,4/31)*D(VFR)+(5,6/31)*0,68*D(VFR) = (1-0,18)*D(VFR)+0,18*0,68*D(VFR)$$

$$= D(VFR)*[1-0,18+0,18*0,68] = D(VFR)*[1-0,18*(1-0,68)]$$

Aug.	31	15,227	491	VFR	98	30.4	521	355	10,792	
------	----	--------	-----	-----	----	------	-----	-----	--------	--

$$\text{Domanda(VFR)} = (\text{Domanda Media Giornaliera})/[1-\%Giorni(IFR)*(1-\%Domanda IFR/VFR)]$$

$$= 375/[1-0,18*(1-0,68)] = 398 \text{ op./giorno}$$

$$\text{Domanda(IFR)} = 398 * 0,68 = 271 \text{ op./giorno}$$

$$375 = (25,4/31)*398+(5,6/31)*271$$

TOTALS:	VFR	74,129	
	IFR	5,404	79,533

Ritardo annuale sulle Runway (2)

TABULATION OF HOURLY DEMAND FOR REPRESENTATIVE DAYS

Clock Time	Daily Ops	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR	VFR	IFR
x:00	8	398	271	414	282	430	292	428	291	436	296	478	325	473	322	521	354	440	299	449	305	440	299	426	290
12-1	.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5-6	.6	2	2	2	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	2	2	3	2
6-7	2.0	8	5	8	6	9	6	9	6	9	6	10	6	9	6	10	7	9	6	9	6	9	6	9	6
7-8	4.1	16	11	17	12	18	12	18	12	18	12	20	13	19	13	21	15	18	12	18	13	18	12	17	12
8-9	7.9	31	21	33	22	34	23	34	23	34	23	38	26	37	25	41	28	35	24	35	24	35	24	34	23
9-10	9.2	37	25	38	26	40	27	39	27	40	27	44	30	44	30	48	33	40	28	41	28	40	28	39	27
10-11	6.7	27	18	28	19	29	20	29	19	29	20	32	22	32	22	35	24	29	20	30	20	29	20	29	19
11-12	5.1	20	14	21	14	22	15	22	15	22	15	24	17	24	16	27	18	22	15	23	16	22	15	22	15
12-13	5.1	20	14	21	14	22	15	22	15	22	15	24	17	24	16	27	18	22	15	23	16	22	15	22	15
13-14	6.1	24	17	25	17	26	18	26	18	27	18	29	20	29	20	32	22	27	18	27	19	27	18	26	18
14-15	6.5	26	18	27	18	28	19	28	19	28	19	31	21	31	21	34	23	29	19	29	20	29	19	28	19
15-16	9.2	37	25	40	26	40	27	39	27	40	27	44	30	44	30	48	33	40	28	41	28	40	28	39	27
16-17	10.2	41	28	42	29	44	30	44	30	44	30	49	33	48	33	53	36	45	30	46	31	45	30	43	30
17-18	9.8	39	27	41	28	42	29	42	29	43	29	47	32	46	32	51	35	43	29	44	30	43	29	42	28
18-19	7.7	31	21	32	22	33	22	33	22	34	23	37	25	36	25	40	27	34	23	35	23	34	23	33	22
19-20	3.5	14	9	14	10	15	10	15	10	15	10	17	11	17	11	18	12	15	10	16	11	15	10	15	10
20-21	2.0	8	5	8	6	9	6	9	6	9	6	10	6	9	6	10	7	9	6	9	6	9	6	9	6
21-22	2.0	8	5	8	6	9	6	9	6	9	6	10	6	9	6	10	7	9	6	9	6	9	6	9	6
22-23	1.2	5	3	5	3	5	4	5	3	5	4	6	4	6	4	6	4	5	4	5	4	5	4	5	3
23-24	.8	3	2	3	2	3	2	3	2	3	2	4	3	4	3	4	3	4	2	4	2	4	2	3	2

Representative daily demand VFR - IFR calculations.

January 12:00 to 13:00 hours.

VFR = 0.051 · 398 = 20

IFR = 0.051 · 271 = 14

Da statistiche

[in %]

$$398 \cdot 2 / 100 \cong 8$$

[operazioni /ora]domanda dalle 20 alle 21

Ritardo annuale sulle Runway (3)

Hour	Miq.	Hourly		D/C Ratio	Mx Index	Arrival Delay		Depart. Delay		Delay Factor DDF	Aver. Delay (Minutes)		Hourly Delay (Minutes)
		Demand	Capacity			Index ADI	Factor ADF	Index DDI	Factor DDF		Arr.	Dsp.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
24:00-01:00		1	-	-	-	-	-	-	-	-	-	-	-
01:00-02:00		0	-	-	-	-	-	-	-	-	-	-	-
02:00-03:00		0	-	-	-	-	-	-	-	-	-	-	-
03:00-04:00		0	-	-	-	-	-	-	-	-	-	-	-
04:00-05:00		0	-	-	-	-	-	-	-	-	-	-	-
05:00-06:00		2	-	-	-	-	-	-	-	-	-	-	-
06:00-07:00		8	-	-	-	-	-	-	-	-	-	-	1
07:00-08:00		16	97	.16	5	1.00	.16	.62	.10	40	.15	.10	2
08:00-09:00		31	97	.32	30	"	.32	.63	.20	"	.55	.25	12
09:00-10:00		37	89	.42	45	"	.42	.65	.27	"	.85	.40	23
10:00-11:00		27	97	.28	30	"	.28	.63	.18	"	.40	.20	8
11:00-12:00		20	"	.21	"	"	.21	"	.13	"	.30	.10	4
12:00-13:00		20	"	.21	"	"	.21	"	.13	"	.30	.10	4
13:00-14:00		24	"	.25	"	"	.25	"	.16	"	.35	.15	6
14:00-15:00		26	97	.27	30	"	.27	.63	.17	"	.40	.15	7
15:00-16:00		37	89	.42	45	"	.42	.65	.27	"	.85	.40	23
16:00-17:00		41	"	.46	"	"	.46	"	.30	"	1.00	.50	31
17:00-18:00		39	89	.44	45	"	.44	.65	.29	"	.90	.45	26
18:00-19:00		31	97	.32	30	"	.32	.63	.20	"	.55	.25	12
19:00-20:00		14	97	.14	5	1.00	.14	.62	.09	40	.10	.10	1
20:00-21:00		8	-	-	-	-	-	-	-	-	-	-	1
21:00-22:00		8	-	-	-	-	-	-	-	-	-	-	1
22:00-23:00		5	-	-	-	-	-	-	-	-	-	-	1
23:00-24:00		3	-	-	-	-	-	-	-	-	-	-	-
											Daily Delay	163	

stima

stima

Ritardo annuale sulle Runway (4)

Month	No. Days	Demand per Month	Ave. Daily Demand	Weather	Percent Occur.	Representative Day(s)			Monthly Delay (minutes)	
						No. of Days	Demand	Delay	VFR/IFR	Total
1	2	3	4	5	6	7	8	9	10	11
Jan.	31	11,631	375	VFR IFR	82 18	25.4 5.6	398 271	163 116	4,140 650	4,790
Feb	28	10,926	390	VFR IFR	80 20	22.4 5.6	414 282	185 130	4,144 728	4,872
Mar.	31	12,561	405	VFR IFR	85 15	26.4 4.6	430 292	199 146	5,254 146	5,926
Apr.	30	12,096	403	VFR IFR	87 13	26.1 3.9	428 291	193 145	5,037 566	5,603
May	31	12,756	411	VFR IFR	90 10	27.9 3.1	436 296	201 148	5,608 459	6,067
June	30	13,508	450	VFR IFR	92 8	27.6 2.4	478 325	278 195	7,673 468	8,141
July	31	13,832	446	VFR IFR	95 5	29.4 1.6	473 322	270 190	7,938 304	8,242
Aug.	31	15,227	491	VFR IFR	98 2	30.4 0.6	521 354	355 251	10,792 151	10,943
Sep.	30	12,456	415	VFR IFR	98 2	29.4 0.6	440 299	209 150	6,145 90	6,235
Oct.	31	13,119	423	VFR IFR	96 4	29.8 1.2	499 305	225 162	6,705 194	6,899
Nov.	30	12,456	415	VFR IFR	90 10	27.0 3.0	440 299	209 150	5,643 450	6,093
Dec.	31	12,432	401	VFR IFR	85 15	26.3 4.7	426 290	192 143	5,050 672	5,722
TOTALS:								VFR IFR	74,129 5,404	79,533